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MCWP 3-17.6 (MCRP 3-17.6A)

SURVIVABILITY OPERATIONS

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HEADQUARTERS, DEPARTMENT OF THE ARMY

Foreword

This publication has been prepared under our direction for use by our respective commands and other commands as appropriate.

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Survivability Operations

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Preface

This publication is part of both the Army's and the Marine Corps' engineer series of doctrinal publications. It updates and consolidates two existing manuals—Field Manual (FM) 5-103 and Army Tactics, Techniques, and Procedures (ATTP) 3-34.39/Marine Corps Reference Publication (MCRP) 3-17.6A—to provide current tactics, techniques, and procedures (TTP) for survivability operations. Although it focuses on engineers' contributions to survivability, this publication is not for engineers only. It provides all Soldiers, Marines, and their leaders with TTP for fighting positions, protective positions, hardened facilities, and camouflage and concealment.

Chapters 1 and 2 provide an overview of survivability operations, including key definitions and constructs, roles and responsibilities, and survivability integration. Chapters 3, 4, and 5 provide TTP for constructing fighting and protective positions and for hardening facilities, while chapter 6 provides TTP for applying camouflage and concealment. Chapters 7 and 8 provide TTP for providing cover, camouflage, and concealment for critical assets and in special environments and situations. The appendixes provide supplemental material. Appendix A provides information on entry control points; appendixes B and C on various reachback and tracking tools; appendix D on bunker and shelter roof design; appendix E on guidelines for standing operating procedures (SOPs); and appendix F on camouflage considerations.

This manual is suitable for Army and Marine Corps commanders/leaders and their staffs at all echelons, but the principal audience for this manual is the engineer staff, primarily officers at brigade/Marine air ground task force (MAGTF) and below who have staff proponency for survivability operations. It is also a valuable reference for Army and Marine Corps trainers, educators, and combat developers, and other Services.

To most effectively use this manual, readers should first become familiar with the foundational doctrine upon which it is built. This includes, among others, Army Doctrine Publication (ADP) 3-0, FM 1-02/MCRP 5-12A, FM 3-34, ADRP 3-37, ADP 5-0, Marine Corps Warfighting Publication (MCWP) 3-17, and MCWP 5-1.

This manual uses joint terms where applicable. Selected joint and Army terms and definitions appear in both the glossary and the text. *Glossary references*: The glossary lists most terms used in Army Techniques Publication (ATP) 3-37.34/MCWP 3-17.6 that have joint or Army definitions. Terms for which ATP 3-37.34/ MCWP 3-17.6 is the proponent publication (the authority) are marked with an asterisk (*) in the glossary. *Text references*: Definitions for which ATP 3-37.34/MCWP 3-17.6 is the proponent publication are boldfaced in the text. These terms and their definitions will be incorporated into the next revision of FM 1-02/MCRP 5-12A. For other definitions in the text, the term is italicized, and the number of the proponent publication follows the definition.

Commanders, staffs, and subordinates ensure their decisions and actions comply with applicable United States (U.S.), international, and, in some cases, host-nation laws and regulations. Commanders at all levels ensure their Soldiers operate in accordance with the law of war and the rules of engagement (see FM 27-10/MCRP 5-12.1A).

This manual uses the term *planning process* to indicate both the military decisionmaking process/Marine Corps Planning Process and troop leading procedures. This manual uses the term mission variables to indicate both the Army and Marine Corps uses of the term. For the Army, mission variables consist of mission, enemy, terrain and weather, troops and support available, time available, and civil considerations, and are abbreviated METT-TC. For the Marine Corps (and in joint doctrine) mission variables consist of mission, enemy, terrain and weather, troops and support available, and time available, and are abbreviated METT-T.

When this manual uses two terms separated by a slash (/); the first term is the Army term, the second term is the Marine Corps term. Key differences in Army and Marine Corps terms include—

- (Army) mission analysis/(Marine Corps) problem framing (written in this manual as mission analysis/problem framing).
- (Army) intelligence preparation of the battlefield/(Marine Corps) intelligence preparation of the battlespace (written in this manual as IPB).

- (Army) scheme of movement and maneuver/(Marine Corps) scheme of maneuver (written in this manual as scheme of movement and maneuver/scheme of maneuver).
- (Army) mission command warfighting function/(Marine Corps) command and control warfighting function (written in this manual as mission command/command and control warfighting function).
- (Army) protection warfighting function/(Marine Corps) force protection warfighting function (written in this manual as protection/force protection warfighting function).

This publication applies to the Marine Corps, Active Army, the Army National Guard/Army National Guard of the United States, and United States Army Reserve and Marine Corps Reserve unless otherwise stated.

The proponent of this publication is the United States Army Engineer School (USAES). The preparing agency is the USAES. Send comments and recommendations on DA Form 2028 (Recommended Changes to Publications and Blank Forms) to Commandant, USAES, ATTN: ATZT-CDC, 14000 MSCoE Loop, Suite 270, Fort Leonard Wood, Missouri 65473-8929, by e-mail to <usarmy.leonardwood.mscoe.mbx.cdidcodddengdoc@mail.mil>; or submit an electronic DA Form 2028.

A listing of preferred metric units of general use is contained in Federal Standard 376B <http://www.usaid.gov/policy/ads/300/fstd376b.pdf>.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

Introduction

Survivability, in its common usage, refers to the capacity, fitness, or tendency to remain alive or in existence. For the Army and Marine Corps, however, survivability is about much more than mere survival—it is also about remaining effective.

When FM 5-103 was published in 1985, survivability was a key aspect of the mobility/countermobility/survivability battlefield operating system. Since then, the battlefield operating systems have been replaced by the warfighting functions. That change included elimination of the mobility/countermobility/survivability battlefield operating system and establishment of the protection/force protection warfighting function which includes survivability. Unfortunately, the definitions and descriptions of survivability and survivability operations were never revised to account for those changes. This manual rectifies that situation. It supersedes FM 5-103, providing revised definitions and descriptions of survivability and survivability operations.

This manual also reflects other changes that have occurred over the 27 years since FM 5-103 was published. While the energy required to move a cubic yard of dirt remains unchanged, and many of the tasks associated with survivability have remained essentially constant, the operational environment has dramatically shifted. Focused threats such as improvised explosive devices (IEDs) and new technologies available to the engineer have caused adjustments in survivability challenges and capabilities. Conversely, the planning process and the commander's concern for protecting personnel and equipment have not changed significantly. What also remains unchanged is the likelihood that the number of survivability tasks (coupled with mobility and countermobility tasks) will challenge engineers to complete them within the prescribed timeframe in support of mission objectives. This manual discusses how leaders and planners can best plan, prepare, execute, and assess survivability operations.

Another major change involves the Army's transformation into a modular force and the effects that this has on doctrine and operations. Other changes that directly affect this manual include the—

- Development and maturation of the term *assured mobility* (see ATTP 3-90.4/MCWP 3-17.8).
- Restructuring of the organic engineer organizations within each of the three types of Army brigade combat teams (BCTs).
- Increased likelihood of joint, interagency, and multinational operations with unified action partners (see ADP 3-0). The primary focus of joint engineer operations is to achieve the commander's intent by coordinating engineer support throughout the joint area of operations. All branches of Service possess organic capability to conduct survivability operations. When available, Navy and Air Force engineer organizations can greatly increase the breadth and depth of the effort (see Joint Publication [JP] 3-34).
- Frequency of contractors on the battlefield and their support for many of the survivability tasks associated with general engineering. (See ATTP 4-10.)
- Resulting changes in the basic design and organizational structures and equipment of engineer organizations to support the Army's ongoing transformation.

This manual modifies several terms as shown in table 1.

Table 1. Modified Army/Marine Corps terms

abatis[1]	survivability [2]	survivability operations[3]
[1] The Army no longer formally defines this term, but still uses it based on standard English.		
[2] Establishes/revises Army/Marine Corps definition (joint definition is insufficient).		
[3] Army proponency transferred from Field Manual 3-34 (definition also modified).		

Chapter 1

Survivability Operations Overview

All personnel and physical assets have some degree of inherent survivability, which is affected by various threats and factors. When a higher degree of survivability is required, survivability operations can often be used to meet that requirement. This chapter defines and describes survivability and the threats and factors affecting it. It then defines and describes survivability operations, including the areas and enablers of survivability operations. Next it discusses survivability operations in the offense, in the defense, and supporting stability or defense support of civil authorities tasks. Finally, it focuses on the engineer role in survivability operations.

SURVIVABILITY

1-1. Although the focus of this manual is on survivability operations, a basic understanding of survivability itself is necessary. The two terms—survivability and survivability operations—are not interchangeable. Whereas survivability refers to a quality or capability, survivability operations are a specific group of activities that enhance survivability. This section defines and describes survivability, providing the basis for understanding the next section, which addresses survivability operations.

1-2. ***Survivability*** **is a quality or capability of military forces which permits them to avoid or withstand hostile actions or environmental conditions while retaining the ability to fulfill their primary mission.** This quality or capability of military forces is closely related to protection (the preservation of a military force's effectiveness) and to the protection/force protection warfighting function (the tasks or systems that preserve the force). (See ADP 3-0, ADRP 3-37, and Marine Corps doctrine publication [MCDP] 1-0 for more information about protection and the protection/force protection warfighting function.)

1-3. Military forces are composed of personnel and physical assets, each having their own inherent survivability qualities or capabilities. These inherent qualities or capabilities can be enhanced through various means and methods. Some (but not all) means and methods for enhancing survivability are provided by survivability operations, which are defined below and are the focus for this manual. Survivability can also be enhanced by other tasks within the protection/force protection warfighting function (see ADRP 3-37), tasks within other warfighting functions, and the factors described below (in paragraph 1-10).

1-4. Some of the means and methods for enhancing survivability become part of the protected personnel or physical asset, enhancing their survivability even while on the move. For example, the body armor worn by Soldiers/Marines enhances their survivability wherever they move (as long as they wear it properly). Other means and methods only enhance survivability at a particular location. For example, an individual fighting position provides no enhanced survivability for Soldiers/Marines unless they remain stationary and occupy it.

1-5. Survivability has two aspects—avoiding and withstanding. The capability to avoid seeks to prevent an attack or to prevent accurate targeting. Susceptibility is the inability to avoid attack and is a function of tactics, countermeasures, probability of enemy attack, and so forth. Normally in a military operation, a force with greater susceptibility has less capability to avoid attack and targeting. The capability to withstand seeks to prevent degradation as a result of having been subjected to an attack. Normally in a military operation, a force with greater vulnerability has less capability to withstand degradation as a result of an attack.

THREATS TO SURVIVABILITY

1-6. There are three general categories of threats described in ADRP 3-37—hostile actions, nonhostile activities, and environmental conditions. Although all three categories of threats can cause damage, destruction, death, or injury to personnel and physical assets, survivability is concerned with avoiding or withstanding threats posed by two of those categories—hostile actions and environmental conditions.

Hostile Actions

1-7. Army and Marine Corps forces today face hybrid threats, which ADP 3-0 describes as the diverse and dynamic combination of regular forces, irregular forces, terrorist forces, criminal elements, or a combination of these forces and elements all unified to achieve mutually benefitting effects. These forces and elements often employ hostile actions to inflict damage upon personnel, physical assets, or information. Such hostile actions pose threats to survivability (which, as previously mentioned, concerns the protection of personnel and physical assets). Hostile actions usually involve employment of weapons. Chapter 3 addresses various types of weapons effects and design considerations to mitigate them.

1-8. Adversaries use sensors to increase the effectiveness of their weapons. Sensor systems are categorized based on the part of the electromagnetic (EM) spectrum in which they operate. Chapter 6 addresses sensor systems and the principles and techniques for using camouflage and concealment to defeat them.

Environmental Conditions

1-9. Hazards associated with the surrounding environment also pose threats to survivability. Weather, natural disasters, and disease are common examples, as are terrain-related hazards. Hazards from environmental conditions are generally outside the scope of this manual and are addressed in FM 3-34.5/MCRP 4.11B and manuals such as ATTP 3-97.11/MCRP 3-35.1D, FM 2-01.3/MCRP 2-3A, FM 3-05.70, FM 3-97.6, FM 90-3/MCWP 3-35.6, FM 90-5, and MCRP 3-02F.

Note. Hostile actions and environmental conditions can sometimes overlap, making it difficult to distinguish between them. Hostile actions can affect environmental conditions and their effects sometimes linger for significant periods of time, such as when chemical, biological, radiological, and nuclear (CBRN) weapons have been employed. In addition, threat forces and elements may, as a hostile action, create hazardous environmental conditions. For example, they may set forest fires or create flooding by destroying a dam. Regardless of whether a particular threat is categorized as a hostile action, an environmental condition, or both, the capability to avoid or withstand such a threat is critical to the survivability of military forces.

FACTORS AFFECTING SURVIVABILITY

1-10. In addition to the threats discussed above, many other factors can affect survivability. Dispersion, redundancy, morale, leadership, and discipline are examples of such factors. This section focuses on the factors of mobility, situational understanding, and terrain and weather conditions, which are among the factors that can enhance the capability to avoid or withstand threats.

Mobility

1-11. Survivability of friendly forces is typically more likely when they are moving or when they possess the ability to reposition quickly. Maintaining freedom of movement and repositioning often increase survivability. Static units must maintain the capability to move on short notice. Because of this, assured mobility is an important factor that can enhance survivability. *Assured mobility* is a framework—of processes, actions, and capabilities—that assures the ability of a force to deploy, move, and maneuver where and when desired, without interruption or delay, to achieve the mission (ATTP 3-90.4/MCWP 3-17.8).

Note. See ATTP 3-90.4/MCWP 3-17.8 for more information about mobility and assured mobility.

Situational Understanding

1-12. Situational understanding is another important factor that can enhance survivability. *Situational understanding* is the product of applying analysis and judgment to relevant information to determine the relationships among the operational and mission variables to facilitate decisionmaking (ADP 6-0). It requires the ability to identify, process, and comprehend the critical elements of information about what occurs inside a commander's area of operation (AO). Having accurate situational understanding provides the baseline for hazard assessments. For example, situational understanding of terrain, through proper terrain analysis, is important to survivability and the development of survivability positions, minimizing the requirements to adjust terrain and leading to the efficient use of survivability assets.

Note. See ADP 5-0, ADP 6-0, and MCWP 5-1 for more information about situational understanding.

Terrain and Weather

1-13. In addition to the threats posed by terrain and weather as part of environmental conditions (discussed above), terrain and weather can also enhance survivability. Existing terrain features (natural or manmade) can provide cover (protection from the effects of fires) and concealment (protection from observation and surveillance). Terrain features can also be reinforced or constructed with natural and manmade materials to provide or enhance cover, concealment, or camouflage. Such terrain-altering activities are commonly called survivability operations, which are discussed in the next section (see paragraph 1-16) and are the focus of this manual.

1-14. Natural and manmade terrain can also enhance survivability by providing shelter from the elements. Terrain features can be reinforced or constructed with natural and manmade materials to provide or enhance shelter. This may be accomplished by erecting tents, constructing field-expedient shelters, or constructing more substantial structures requiring engineer support.

Note. There is a close connection between cover (protection from the effects of fires) and shelter from the elements. Often, things that provide cover also provide some shelter from the elements—and vice versa. This is particularly true when considering CBRN weapons, since many of their effects have similar characteristics to some weather conditions. This manual focuses on terrain-altering activities that provide cover, concealment, and camouflage. Activities aimed at providing shelter from the elements, with no intent to protect from the effects of fires (for example, unhardened snow shelters), are outside the scope of this manual. See FM 3-05.70 and MCRP 3-02F for information about field-expedient shelters. See FM 3-34.400/MCWP 3-17.7 for information about general engineering support, much of which is directed at constructing structures that provide shelter from the elements.

1-15. Weather conditions can also enhance survivability. For example, the reduced visibility caused by fog or snow can provide concealment for personnel and physical assets, reducing the effectiveness of threat sensor systems. (See chapter 8 for additional discussion about weather effects in special environments.)

SURVIVABILITY OPERATIONS

1-16. As discussed in the previous section, personnel and physical assets have inherent survivability qualities or capabilities which can be enhanced through various means and methods. One way to enhance survivability—when existing terrain features offer insufficient cover and concealment—is to alter the physical environment to provide or improve cover and concealment. Similarly, natural or artificial materials may be used as camouflage to confuse, mislead, or evade the enemy. Together, these are called ***survivability operations*****—those military activities that alter the physical environment to provide or**

improve cover, concealment, and camouflage. By providing or improving cover, concealment, and camouflage, survivability operations help military forces avoid or withstand hostile actions. Although such activities often have the added benefit of providing shelter from the elements, survivability operations focus on providing cover, concealment, and camouflage.

1-17. All units conduct survivability operations within the limits of their capabilities. Engineer and CBRN personnel and units have additional capabilities to support survivability operations. Engineer support to survivability operations is a major portion of the enhance protection line of engineer support (described in FM 3-34 and discussed below in paragraphs 1-37 and 1-38). CBRN support to survivability operations includes the employment of obscurants, which can be used to enable survivability operations by concealing friendly positions and screening maneuvering forces from enemy observation. (See FM 3-11.50 for additional information about employing obscurants.)

1-18. Although survivability encompasses capabilities of military forces both while on the move and when stationary, survivability operations focus more on stationary capabilities—constructing fighting and protective positions and hardening facilities. In the case of camouflage and concealment, however, survivability operations include both stationary and on-the-move capabilities.

1-19. Conducting survivability operations is one of the tasks of the protection/force protection warfighting function, but survivability operations can also be used to enable other warfighting functions. For example, military deception—part of the mission command/command and control warfighting function—can be enabled by the use of survivability operations intended to help mislead adversary decisionmakers. This may include the use of dummy or decoy positions or devices. For more information about military deception see FM 3-13, ADRP 3-37, JP 3-13.4, and MCRP 3-40.4A/ Navy Tactics, Techniques, and Procedures (NTTP) 3-58.1/Air Force Tactics, Techniques, and Procedures (Interservice) (AFTTP[I]) 3-2.66.

Areas of Survivability Operations

1-20. Survivability operations enhance the ability to avoid or withstand hostile actions by altering the physical environment. They accomplish this by providing or improving cover, concealment, and camouflage in four areas. The first three areas address fighting positions, protective positions, and hardened facilities, focusing on providing cover (although not excluding camouflage and concealment). The fourth area addresses camouflage and concealment and focuses on providing protection from observation and surveillance. All four areas (but especially the first three) often have the added benefit of providing some degree of shelter from the elements. The four areas of survivability operations are often addressed in combination. Fighting positions and protective positions, for example, usually also require camouflage and concealment. Camouflage and concealment activities often accompany activities to harden facilities. This manual focuses on the application of the four areas of survivability operations at the brigade/MAGTF and below.

Fighting Positions

1-21. The purpose of a fighting position is to allow Soldiers/Marines and their weapon systems to engage and destroy enemy forces while avoiding or withstanding hostile actions. Such positions include individual, crew-served, and combat vehicle positions, as well as bunkers and towers. Fighting positions provide cover and (often) camouflage and concealment and, to be effective, they must also support the unit's defensive plan. This requires close integration with the concept of operations and its supporting schemes, particularly the scheme of movement and maneuver/scheme of maneuver and the scheme of fires. See chapters 3 and 4 for more information about fighting positions.

Protective Positions

1-22. The purpose of a protective position is to protect the personnel, vehicles, and equipment occupying the position by allowing them to avoid or withstand hostile actions. As with fighting positions, protective positions provide cover, camouflage, or concealment (or a combination of the three). Unlike fighting positions, protective positions are not focused on providing a position from which to engage the enemy. See chapters 3 and 5 for more information about protective positions.

Hardened Facilities

1-23. Military forces use many facilities in addition to fighting and protective positions. When enhanced protection is required for a facility, it can be hardened to provide or improve cover to the structure and its occupants. Hardening helps to avoid or withstand hostile actions and is accomplished by using barriers, walls, shields, berms, or other types of physical protection. Chapter 3 provides additional information on designing hardened facilities.

1-24. Hardening of facilities also includes the use of bridge protective devices such as antimine booms, impact booms, and antiswimmer nets. These devices typically protect bridges or crossing sites from waterborne demolition teams, floating mines, or floating debris (see ATTP 3-90.4/MCWP 3-17.8).

Camouflage and Concealment

1-25. Camouflage and concealment are materials and techniques used to hide, blend, disguise, or disrupt the appearance of military targets and their backgrounds to prevent visual and electronic detection of friendly forces. Camouflage and concealment helps to avoid or withstand hostile actions by preventing an enemy from detecting or identifying friendly troops, equipment, activities, or installations.

1-26. Camouflage uses natural or artificial materials on personnel, objects, and tactical positions to confuse, mislead, or evade the enemy. It contributes to survivability by causing the enemy not to even consider these things as a target; or it confuses the enemy as to the nature, parameters, or specifics associated with those potential targets. For instance, camouflage nets may be used to conceal vehicles, tents, shelters, and equipment while vegetation is generally used to disrupt the outline of the target rather than completely hide it.

1-27. Concealment uses terrain and other natural or manmade features to protect from observation and surveillance. Along with cover, concealment is one of the five military aspects of terrain which commanders use to analyze terrain during mission analysis/problem framing. Concealment must be considered when identifying potential friendly positions such as assembly areas (AAs), routes, assault positions, and battle positions (BPs). Chapter 6 provides TTP for camouflage and concealment.

Enablers of Survivability Operations

1-28. In addition to activities that alter the physical environment to provide or improve cover, concealment, and camouflage, other capabilities and activities can be used to conduct or support survivability operations. These capabilities and activities, when properly integrated, are effective enablers of survivability operations. An enabler of survivability operations refers to a military capability or activity whose primary purpose is other than survivability operations, but can be used for conducting or supporting survivability operations. Common enablers include military deception, protective obstacles, and obscuration. Commanders consider other activities in addition to this list based on the mission and operational environment.

1-29. *Military deception* is defined as those actions executed to deliberately mislead adversary decisionmakers as to friendly military capabilities, intentions, and operations, thereby causing the adversary to take specific actions (or inactions) that will contribute to the accomplishment of the friendly mission (JP 3-13.4). Military deception enables survivability operations by presenting enemy forces with false information; thereby causing them to expend ordnance or resources on nonthreatening targets. That, in turn, improves the effectiveness of survivability operations. For more information about military deception see FM 3-13, ADRP 3-37, JP 3-13.4, and MCRP 3-40.4A/NTTP 3-58.1/AFTTP(I) 3-2.66.

1-30. Protective obstacles, though often considered as part of countermobility operations, are a key enabler to survivability operations. They provide the friendly force with close-in protection, which enhances the effectiveness of survivability positions. (For more information about protective obstacles, see FM 90-7.)

1-31. One major enabler of concealment is obscuration—the effects of weather, battlefield dust, and debris, or the use of smoke munitions (or other potential obscurants) to hamper observation and target-acquisition capability or to conceal activities or movement. Battlefield obscuration is typically provided by specialized CBRN elements or fires. Additional information about the employment of obscurants is in FM 3-11.50.

SURVIVABILITY OPERATIONS IN THE OFFENSE

1-32. In the offense, fighting and protective position development is minimal for tactical vehicles and weapons systems. Camouflage and concealment will typically play a greater role in survivability during offensive tasks than the other areas of survivability operations will. Protective positions for artillery, air and missile defense (AMD), and logistics positions, however, may still be required in the offense. Stationary command posts (CPs), and other facilities for the mission command/command and control warfighting function, may also require protection to lessen their vulnerability. During halts in the advance, while the use of terrain will provide a measure of protection, units should still develop as many protective positions as necessary for key weapons systems, CPs, and critical supplies based on the threat level and unit vulnerabilities. During the early planning stages, geospatial engineer teams can provide information on soil conditions, vegetative concealment, and terrain masking along march routes to facilitate survivability for the force.

SURVIVABILITY OPERATIONS IN THE DEFENSE

1-33. Defensive missions typically demand the most effort and resources for survivability operations. Activities in the defense include constructing survivability positions for CPs, artillery, AMD, and critical equipment and supplies. They also include preparing individual and crew-served fighting positions and defilade fighting positions for combat vehicles. Survivability efforts must consider threats from conventional (direct and indirect fires) and also unconventional threats (such as suicide bombing and vehicle-borne improvised explosive devices [VBIEDs]). The relative amount of survivability effort placed against these threats will depend on the threat analysis and the available resources. During this period, countermobility efforts will compete with survivability for resources and assets. Because of this, it is critical that commanders provide clear guidance on resources and priorities of effort.

1-34. In the development of defensive fighting positions, proper siting must consider both the surrounding terrain and the most effective employment of key weapons systems in relationship to designated engagement areas (EAs). Defensive protective positions include, but are not limited to, CPs, signal nodes (and other facilities for the mission command/command and control warfighting function), critical equipment (to include radars), supply and ammunition storage/holding areas, and other items that are likely to be targeted by enemy action. Consider protecting hazardous material and petroleum, oil, and lubricants (POL) storage areas against both material loss and health threats to personnel if the storage containers are damaged or destroyed. The degree of protection actually provided for these items is based upon the availability of time, equipment, and resources. An additional consideration is the probability/risk of acquisition/attack and the risk assessment made for each site/facility. Facilities emitting a strong EM signal or substantial thermal and/or visual signature may require full protection against potential enemy attack. Electronic countermeasures and military deception activities are an integral part of planning for all activities in the defense.

SURVIVABILITY OPERATIONS SUPPORTING STABILITY OR DEFENSE SUPPORT OF CIVIL AUTHORITIES TASKS

1-35. When conducting stability or defense support of civil authorities tasks, survivability remains a key commander concern and may require significant effort applied to survivability operations. Although the likelihood of combat operations is reduced, key resources and personnel remain vulnerable to conventional and unconventional threats.

1-36. Commanders must consider protecting vital resources such as fuel sites, ammunition holding areas, living areas, and other logistics support areas since the entire AO has a greater potential for enemy attack. The priority of work will be much more focused on protecting these types of resources than on constructing fighting positions for combat vehicles or crew-served weapons. Vital resources requiring protection may also include facilities critical to the civilian infrastructure such as key industrial sites, pipelines, water treatment plants, and government buildings.

ENGINEER ROLE IN SURVIVABILITY OPERATIONS

1-37. Although all units conduct survivability operations within the limits of their capabilities, the Army and Marine Corps have a broad range of diverse engineer capabilities that can enhance survivability. Engineering tasks in support of survivability operations include tasks to build, repair, or maintain fighting and protective positions; and harden, conceal, or camouflage roads, bridges, airfields, and other structures and facilities. These tasks tend to be equipment intensive and may require the use of equipment timelines to optimize use of low-density, critical equipment.

1-38. The Army groups its engineer capabilities into three engineer disciplines—combat, general, and geospatial engineering—and employs capabilities from all three disciplines to support survivability operations. The Army uses four lines of engineer support to help commanders and staffs combine the capabilities from all three engineer disciplines and align their activities according to their purpose. Of the four lines of engineer support (described in FM 3-34), engineer support to survivability operations is most often aligned with the line of engineer support to enhance protection. This line of engineer support is the combination of engineer disciplines to support the preservation of the force so the commander can apply maximum combat power. It consists largely of survivability tasks, but also can include selected mobility, countermobility, and explosive hazard (EH) operations tasks. Geospatial engineering tasks also support this line. (See FM 3-34 for more information about the Army's engineer disciplines and lines of engineer support.)

1-39. The Marine Corps groups its expeditionary engineering capabilities into four lines of engineer support. Survivability tasks are included within Enhance Protection. Tasks such as construction of field fortifications (hardening of command, communication and combat train locations, weapon system firing positions, and infantry fighting positions) are critical to MAGTF efforts to reduce exposure to threat acquisition, targeting, and engagement. (See MCWP 3-17 for more information about Marine Corps engineering.)

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Chapter 2

Integration of Survivability Operations

Competing demands and limited resources for conducting survivability operations will be a predominant factor in the operational environment. Careful planning, prioritization, and allocation of those resources must occur to accomplish objectives. This chapter centers on planning, preparing, executing, and assessing survivability operations. The construct of essential tasks for mobility, countermobility, and/or survivability (M/CM/S); and inclusion in the running estimate are highlighted to assist planners in integrating survivability operations.

ROLES AND RESPONSIBILITIES

2-1. Roles and responsibilities for integrating survivability operations may vary based on the organization of functional and integrating cells at different echelons, and should be prescribed in unit SOPs. This section presents guidelines for roles and responsibilities for survivability operations at the brigade/MAGTF level and below.

COMMANDER

2-2. The challenging and unpredictable nature of operational environments requires that commanders at every echelon thoroughly understand survivability requirements and issue clear intent, guidance, and prioritization for any survivability operations conducted by or in support of their unit. The commander uses the construct of essential tasks for M/CM/S to prioritize actions and concentrate survivability efforts. (See FM 3-34 for additional information about essential tasks for M/CM/S.) Commanders must understand their survivability requirements across the range of military operations and the capabilities of available assets to perform survivability operations within the AO. The commander provides focus through the essential tasks for survivability during planning and preparation, enforces safety and construction standards during execution, and continuously assesses the effectiveness of survivability against expected threats.

2-3. In addition to the responsibilities shared by all commanders, engineer commanders at every echelon must also completely understand the capabilities and requirements of the supported unit and understand how best to integrate engineers as part of combined arms operations. The engineer commander ensures that survivability missions are properly planned, designed, and constructed to standard. The engineer commander works together with the appropriate engineer staff officer to ensure that the survivability effort is synchronized and meets the needs of the supported unit.

ENGINEER STAFF OFFICER

2-4. The engineer staff officer is a special staff officer and is typically the senior engineer officer on staff. The engineer staff officer is responsible for coordinating engineer assets and operations for the BCT/regimental combat team (RCT) (including engineer support to survivability operations) and—

- Advises the commander on engineer assets and capabilities.
- Makes recommendations on the priority of engineer effort based on the commander's guidance.
- Develops recommended essential tasks for M/CM/S.
- Makes recommendations on engineer task organization and determines if additional assets are needed to execute the anticipated engineer tasks.
- Integrates survivability guidance and tasks into mission orders and monitors execution.

OTHER STAFF OFFICERS

2-5. The operations staff officer (S-3) is the coordinating staff officer for all matters concerning tactical operations. In the BCT, the S-3 supervises the protection cell. The S-3 integrates and synchronizes survivability efforts within the scheme of movement and maneuver/scheme of maneuver based on recommendations from the engineer staff officer. The CBRN officer and the provost marshal are typically major contributors to the planning and resourcing of survivability operations.

2-6. The intelligence staff officer (S-2) provides information on enemy capabilities and expected enemy courses of action (COAs), to allow the engineer planner to plan and recommend the type and amount of survivability positions needed to protect friendly forces.

2-7. The logistics staff officer (S-4) is responsible for planning and executing logistical requirements for operations. This includes the delivery of fuel, construction and barrier material, and ammunition. The S-4 coordinates for the establishment of logistics sites and materials issued to forward units based on the mission. Survivability missions are often very resource intensive. Early coordination with the S-4 is essential to ensure that adequate types and quantities of materials and transportation assets are available to support the mission.

2-8. Depending on the situation, other staff officers may also play a role in integrating survivability operations. For example, the CBRN officer and the surgeon coordinate Army health system support requirements for CBRN operations, some of which may involve survivability operations. Since survivability operations (and their resulting positions and structures) may involve significant safety risk, the safety officer advises and assists with risk management and compliance with safety requirements.

PROTECTION CELL

2-9. The protection cell integrates and synchronizes protection tasks and their associated systems (see ADRP 3-37) throughout the operations process. The risk management process (see FM 5-19) is the overarching process for integrating protection into Army operations. The protection cell coordinates with the mission command cell to facilitate the information protection task. In the BCT, the S-3 supervises the protection cell.

2-10. Protection integration in the BCT/RCT may require commanders to designate a staff lead, as the protection officer, who has the experience to integrate risk management and other integrating processes. The executive officer, S-3, or a senior noncommissioned officer (NCO) (Army)/senior staff NCO (Marine Corps) could accomplish these duties. Assistant operations officers and other staff officers could be designated as the protection coordinators to facilitate the integration of the protection tasks into operations. In all cases, protection officers and coordinators work with higher and lower echelons to nest protection activities with complementary and reinforcing capabilities.

PLANNING

2-11. Planning survivability operations is supported by the construct of the engineer's running estimate during the planning process described in ADP 5-0 and MCWP 5-1. As part of the combined arms team conducting the planning process, engineers and other planners focus their efforts on specific considerations for survivability for each step of the process (see table 2-1).

Table 2-1. Survivability planning considerations during the planning process

Steps of the MDMP	***Steps of the MCPP***	***Survivability Planning Considerations***
Receipt of the Mission	Problem Framing	• Receive higher headquarters plans, orders, and annexes. • Understand the unit's mission, concept of the operation, and commander's intent and priorities for survivability (two levels up). • Understand the engineer mission, intent, and scheme of engineer operations (two levels up). • Understand higher echelon's essential tasks for M/CM/S.
Mission Analysis		• Identify specified and implied tasks for survivability; develop recommended list of essential tasks for survivability (for the commander's approval during the mission analysis/problem framing brief). • Initiate RFIs. • Evaluate terrain, climate, and threat capabilities to determine the potential impact on survivability. • Determine the availability of construction and other engineering materials. • Review the availability of survivability capabilities to include Army/Marine Corps, joint, multinational, HN, and by contract. • Determine protection requirements for supported force. • Review existing data from reconnaissance or assessments. • Determine the threat (to include environmental and EHs). • Determine survivability related IRs (terrain and mobility restraints, threat capabilities, and critical infrastructure) and make recommendations for inclusion in the CCIR as necessary. • Integrate survivability IRs into the R&S plan. • Provide the commander with suggested guidance for survivability operations that can be included in the commander's guidance for COA development.
COA Development	COA Development	• Identify priority survivability requirements. Refine essential tasks for survivability (if necessary). • Integrate survivability support into COA development and in the scheme of engineer operations for each COA. • Array survivability assets using task and purpose. • Recommend an appropriate level of protection effort for each COA based on the expected threat. • Develop COA evaluation criteria focused on survivability efforts.
COA Analysis	COA Wargaming	• Refine the survivability plan based on results of wargaming.
COA Comparison	COA Comparison and Decision	• Provide advantages and disadvantages of each COA from the survivability perspective, such as: ability to support, risk to forces or equipment.
COA Approval		• Gain approval for any changes to the essential tasks of survivability. • Gain approval for survivability priorities of effort and support. • Gain approval for requests for engineer augmentation to be sent to higher headquarters.

Table 2-1. Survivability planning considerations during the planning process (continued)

Steps of the MDMP	*Steps of the MCPP*	*Survivability Planning Considerations*
Orders Production, Dissemination, and Transition	Orders Development Transition	• Provide input to the appropriate plans and orders. • Ensure that all engineer forces and critical equipment are properly allocated in the task organization.

Note.
The Army uses the military decisionmaking process (MDMP) and the Marine Corps uses the Marine Corps Planning Process (MCPP). The processes are similar, although the steps are different. The MDMP is described in ADP 5-0 and the MCPP is described in MCWP 5-1.

Legend:
CCIR – commander's critical information requirementsCOA – course of action
EH – explosive hazard
HN – host nation
IR – information requirement
M/CM/S – mobility, countermobility, and/or survivability
R&S – reconnaissance and surveillance
RFI – request for information

THE ENGINEER STAFF'S RUNNING ESTIMATE

2-12. The engineer staff's running estimate is a logical thought process and extension of the planning process. It is conducted by the engineer staff officer, concurrently with the planning process of the supported maneuver force, and is continuously maintained throughout planning, preparation, execution, and assessment. This running estimate allows for early integration and synchronization of essential tasks for M/CM/S into the planning process. It drives the coordination between the engineer, the supported commander, and other staff members in the development of engineer plans, orders, and annexes. Table 2-2 shows the relationship between mission analysis/problem framing during the planning process and the engineer's running estimate, including identification of essential tasks for M/CM/S.

Table 2-2. Correlation of mission analysis/problem framing and the engineer's running estimate

Mission Analysis/Problem Framing	*Engineer's Running Estimate*
• Analyze the higher headquarters plan or order. • Perform initial IPB. • Determine specified, implied, and essential tasks. • Review available assets and identify resource shortfalls. • Determine constraints. • Identify critical facts and develop assumptions. • Begin risk management. • Develop initial CCIRs and EEFIs. • Develop initial R&S synchronization tools. • Update the plan for the use of available time. • Develop initial themes and messages. • Develop a proposed problem statement. • Develop a proposed mission statement.	• Analyze the higher headquarters orders, to include— ▪ Commander's intent. ▪ Mission. ▪ Concept of operation. ▪ Timeline. ▪ AO. • Conduct IPB, to include— ▪ Terrain and weather analysis. ▪ Enemy mission and M/CM/S capabilities. ▪ Friendly mission and M/CM/S capabilities. • Analyze the engineer mission, to include— ▪ Specified M/CM/S tasks. ▪ Implied M/CM/S tasks. ▪ Assets available. ▪ Limitations. ▪ Risk as applied to engineer capabilities. ▪ Time analysis. ▪ Identified essential tasks for M/CM/S. ▪ Restated mission.

Table 2-2. Correlation of mission analysis/problem framing and the engineer's running estimate (continued)

Mission Analysis/Problem Framing	*Engineer's Running Estimate*
• Present the mission analysis/problem framing briefing. • Develop and issue the initial commander's intent. • Develop and issue the initial planning guidance. • Develop COA evaluation criteria. • Issue a warning order.	• Conduct risk assessment, to include— ▪ Safety. ▪ Environment. • Determine CCIR (terrain and mobility restraints, obstacle intelligence, threat engineer capabilities, and critical infrastructure). • Integrate engineer reconnaissance effort.
Legend: AO – area of operations CCIR – commander's critical information requirement COA – course of action EEFI – essential elements of friendly information	IPB – intelligence preparation of the battlefield/battlespace M/CM/S – mobility, countermobility, and/or survivability R&S – reconnaissance and surveillance

2-13. The running estimate parallels the planning process. Mission analysis/problem framing, facts and assumptions, and analysis of the mission variables furnish the structure for running estimates. In the running estimate, the engineer staff continuously considers the effects of new information and updates the following:

- Facts.
- Assumptions.
- Friendly force status (assessment of M/CM/S capabilities to ongoing and planned operations).
- Enemy activities and capabilities (that can affect current operations and future plans).
- Civil considerations (effects on current engineer operations and future plans).
- Conclusions and recommendations.

2-14. The running estimate provides the basis for action. When an estimate reveals a variance that requires correction, staff representatives act within their authority to correct it. When the decision required is outside their authority, they present the situation to the staff officer delegated the authority to act or to the commander. When the estimate reveals information that answers an information requirement, especially a commander's critical information requirement, engineer staff representatives send that information to the element requiring it. Engineer staff representatives do more than collect and store information; they process it into knowledge and apply judgment to get the knowledge to those requiring it.

ESSENTIAL TASKS FOR SURVIVABILITY

2-15. Increased engineer requirements in the operational environment may limit engineer resources immediately available to support survivability operations. Other engineer tasks are often in competition for the same engineer assets. Early integration and the establishment of priorities are essential to allocate resources and ensure adequate time for mission completion. The commander sets priorities to allow the force to perform the most critical tasks. Planners (typically elements such as engineer, CBRN, military police, or explosive ordnance disposal) assist the commander in his decision by providing recommended essential tasks for survivability during mission analysis/problem framing. They develop the recommended essential tasks for survivability in conjunction with the staff's development of the critical asset list and the defended asset list and as part of EA development and combined arms obstacle planning. (For information about the critical asset list and defended asset list see ADRP 3-37. For information about EA development and combined arms obstacle planning see FM 90-7.) After the essential tasks for survivability are approved, the engineer staff officer and other planners integrate them into COA development. They develop associated methods to complete the essential tasks for survivability by assigning resources and recommending priorities. The engineer staff officer and other planners, in coordination with the maneuver planner, then synchronize the methods to achieve the desired effects on enemy or friendly forces. A fully developed essential task for survivability includes the task and the purpose, described as follows:

- **Task**. A task is a measurable action performed by individuals or organizations. These are the most important survivability tasks which must be accomplished. Often the entire operation is dependent on completing these tasks, and without their successful completion, the operation is at risk.
- **Purpose**. The purpose is the desired or intended result of the task stated in terms relating to the purpose of the supported unit. This portion of the essential task for survivability explains why it must be accomplished. It also provides intent to the engineer commander so that he can react as the situation changes.

2-16. The commander uses essential tasks for survivability to communicate to subordinate units what he wants accomplished with available assets to perform survivability tasks. This provides the unit with clear priorities and unity of purpose in planning, preparing, and executing. Essential tasks for survivability also provide nonengineer elements clearly articulated tasks related to survivability. Example engineer-related essential tasks for survivability might include—

- **Essential task for M/CM/S #1**.
  - **Task**: Construct primary and supplementary fighting positions for all vehicles and crew-served weapons at BP Patriots.
  - **Purpose**: To provide Alpha Company with effective cover and concealment from direct and indirect fire during their defense of Task Force England's western flank.
- **Essential task for M/CM/S #2**.
  - **Task**: Construct revetments and berms around the bulk fuel site at forward operating base Bears.
  - **Purpose**: To provide effective cover from direct and (near miss) indirect fire for 1st Brigade's fuel supply.

PREPARATION

2-17. Preparing to execute survivability operations begins as relevant information and guidance are developed during the planning phase. The early identification of the essential tasks for survivability during planning initiates the requisitioning and transportation of survivability materials (such as soil-filled containers, concrete barriers, and construction materials) and prompts any requests for unit augmentation. The use of warning orders and planning in parallel facilitates early coordination between engineer and supported units, the pre-positioning of equipment and materials, and the preliminary design work for survivability positions.

2-18. Based on the task organization, survivability guidance, the identification of critical assets (such as command and control nodes and air defense systems), and locations of unit positions; subordinate engineers begin coordinating survivability efforts with supported units. Early initiation of troop movements and the pre-positioning of survivability assets and materials within the AO enable the timely execution of survivability operations.

2-19. Certain survivability measures, such as protective positions and facility hardening, may require significant design efforts. Engineers coordinate with the supported unit, conduct reconnaissance and assessments, and develop designs. Designs are verified to ensure that they defeat the specified threat, meet safety requirements, and that bills of material are correct. Tele-engineering and other reachback capabilities (see appendix B) can aid designing efforts. Basic survivability design concerns are discussed in chapter 3.

2-20. During preparation, the engineer's running estimate continues to track resource status. Priority for assessment is on answering priority intelligence requirements and friendly forces information requirements that fall within the engineer's area of expertise. Assessing during preparation also includes confirming or disproving any assumptions that were made during planning.

EXECUTION

2-21. Survivability missions should begin as soon as possible (sometimes even before completion of the supported unit's planning) to maximize the amount of survivability support that can be provided. Execution

involves monitoring the situation, assessing the operation, and adjusting the order as needed. Fighting and protective positions are constructed, facilities are hardened, and camouflage and concealment measures are implemented. Units track the completion of missions and reallocate resources as the situation requires. Quality assurance and quality control are implemented to ensure that survivability efforts meet the commander's intent and also meet proper design and construction standards to ensure safety.

2-22. During execution, the engineer's running estimate focuses on identifying any variances, assessing their effect on achieving the end state, and recommending corrective actions to keep the operation within the commander's intent. Assessments also address the supportability of possible sequels and future operations.

ASSESSMENT

2-23. Survivability measures are continuously assessed for effectiveness. Assisted by the staff, commanders compare the current situation with forecasted outcomes (evaluation) using measures of performance and measures of effectiveness (see ADP 5-0 and MCDP 1-0) to judge progress toward success. Staffs analyze the situation in terms of the mission variables (or operational variables or both) to understand the mission and prepare their running estimates. They continuously assess the effects of new information on the conduct of the operation; they update their running estimates and determine if adjustments to decisions are required. As threat conditions change, enemy tactics adapt, and lessons are learned, new survivability measures are established and implemented. This may include changes in employment methods, design modifications, and the use of different or improved materials.

TRACKING TOOLS

2-24. Several tools may assist engineers, other staff, and commanders in tracking survivability operations. Survivability timelines and matrices are used to indicate priorities of effort, track progress, and update the commander on the status of survivability operations. Examples of a survivability capabilities card and other tracking tools are provided in appendix C.

2-25. The survivability timeline helps leaders understand the employment of engineer assets and the timing for initiating and completing survivability missions. It can include link-up times and locations, the designation of units supporting the task, and the duration of engineer efforts for a specific area. It synchronizes the effort by establishing time limits for completing site layout and marking fighting positions before the arrival of engineer equipment. A timeline also provides a visual display of asset employment, assisting the staff in ensuring optimal use of engineer equipment.

2-26. The survivability matrix can be used to show the commander the amount of survivability effort for each unit or BP. It provides an estimate of the type and number of fighting or protective positions to be accomplished within a designated timeframe.

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Chapter 3
Cover

When existing cover is insufficient, commanders can use survivability operations to provide or improve cover by altering the physical environment. Of the four areas of survivability operations, three involve providing or improving cover, which protects personnel and physical assets from fires by mitigating their effects. This chapter describes types of weapons effects and considerations for mitigating them. It also describes various techniques that can be employed for providing or improving cover.

TYPES OF WEAPONS EFFECTS

3-1. Providing or improving effective cover requires a thorough understanding of types of weapons effects. This section provides an overview of the effects of direct- and indirect-fire projectiles, EHs, and CBRN agents and weapons.

DIRECT FIRE

3-2. Direct-fire projectiles are primarily designed to strike a target with a velocity high enough to achieve penetration. In this section, two types of direct-fire weapons effects are discussed: chemical and kinetic.

Chemical Energy Projectile

3-3. Chemical energy projectiles use some form of chemical heat and blast to achieve penetration. They detonate either at impact or when maximum penetration is achieved. Chemical energy projectiles carrying impact-detonated or delayed detonation high explosive (HE) charges are used mainly for direct fire from systems with high accuracy and consistently good target acquisition ability. Tanks, antitank (AT) weapons, and automatic cannons usually possess the capability for using this type of projectile.

3-4. HE rounds include high explosive antitank (HEAT) rounds, recoilless rifle rounds, and AT rockets. They are designed to detonate a shaped charge on impact. At detonation, an extremely high velocity molten jet is formed. This jet perforates large thicknesses of high-density material, continues along its path, and sets fuel and ammunition on fire. The HEAT rounds generally range in size from 60 to 125 millimeters.

Kinetic Energy Projectile

3-5. Kinetic energy projectiles use high velocity and mass (momentum) to penetrate their target. Kinetic energy direct-fire projectiles include ball and tracer, armor piercing, and armor piercing incendiary rounds.

3-6. Ball and tracer rounds are normally of a relatively small caliber (5.56 to 14.5 millimeters) and are fired from pistols, rifles, and machine guns. The round's projectile penetrates soft targets on impact at a high velocity. The penetration depends directly on the projectile's velocity, weight, and angle at which it hits.

3-7. Armor piercing and armor piercing incendiary rounds are designed to penetrate armor plate and other types of homogeneous steel. Armor piercing projectiles have a special jacket encasing a hard core or penetrating rod which is designed to penetrate when fired with high accuracy at an angle very close to the perpendicular of the target. Incendiary projectiles are used principally to penetrate a target and ignite its contents. They are used effectively against fuel supplies and storage areas.

INDIRECT FIRE

3-8. Indirect-fire projectiles used against protective positions include rifle grenades, mortars, artillery, missiles, rockets, and aircraft-delivered ordnance which cause blast, incendiary, and fragmentation damage to affected structures.

3-9. Blast caused by the detonation of an explosive charge creates a shock wave which knocks apart walls or roof structures. Contact bursts cause excavation cave-in from ground shock or structure collapse. Overhead bursts can buckle or destroy the roof. Blasts from HE shells or rockets can occur in the following three ways:

- Overhead or proximity burst (fragmentation from an artillery airburst shell).
- Contact burst (blast from an artillery shell exploding on impact).
- Delay-fuze burst (blast from an artillery shell designed to detonate after penetration into a target).

3-10. The severity of blast effects increases as the distance from the structure to the point of impact decreases. Delay-fuze bursts are the greatest threat to covered structures. Repeated surface or delay-fuze bursts further degrade fighting and protective positions by the cratering effect and soil discharge. Indirect-fire blast effects also cause concussions. The shock from an HE round detonation causes headaches, nosebleeds, and spinal and brain concussions. It may also cause a spalling effect against certain materials.

3-11. Fragmentation occurs when the projectile disintegrates, producing a mass of high-speed steel fragments which can perforate and become imbedded in fighting and protective positions. The pattern or distribution of fragments greatly affects the design of fighting and protective positions. Airburst of artillery shells provides the greatest unrestricted distribution of fragments. Fragments created by surface and delay bursts are restricted by obstructions on the ground.

EXPLOSIVE HAZARDS

3-12. EHs include mines, unexploded ordnance (UXO) and ammunition, IEDs, and booby traps that were dropped, projected, thrown, or emplaced in past conflicts or in support of current operations. These hazards are often difficult to detect and present serious concerns across the range of military operations. (See FM 3-34.210/MCRP 3-17.2D and FM 3-90.119/Marine Corps Interim Publication (MCIP) 3-17.01 for additional information.)

3-13. An IED is a homemade explosive device designed to cause injury or death by use of explosives alone or in combination with chemical, biological, or radiological materials. IEDs can use homemade explosives or military ordnance and ordnance components. IEDs can be detonated directly or remotely and include VBIEDs and suicide bombers. VBIEDs have a capability to inflict large-scale damage to facilities and cause multiple casualties.

3-14. Booby traps, whether using standard munitions or IEDs, are designed to be activated by the victim. They are placed in buildings, under rubble, and are connected to items of equipment and sometimes human remains. Like IEDs and VBIEDs, they create psychological and physical threats. While designed primarily to attack personnel, they may also damage or destroy equipment.

3-15. Mines and UXO are located on the battlefield and are often left over from previous conflicts. Like IEDs and booby traps, they can be difficult to detect and neutralize. They may often be encountered during the conduct of stability tasks when those tasks take place in areas that have experienced armed conflict. UXO are also encountered on the training areas of military installations, and also occur when ammunition storage facilities have been attacked during a conflict.

CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR THREATS AND HAZARDS

3-16. The large variety of CBRN threats and hazards includes weapons of mass destruction, CBRN agents, and toxic industrial material. The mechanisms for dissemination of contamination differ in that biological and chemical weapons either undergo low-order detonations or employ some less violent form of release to

disperse the agent without destroying it; whereas, nuclear weapons can produce radioactive contamination from an explosion or a simple rupture, and the extent of contamination increases with the violence of the event.

3-17. Traditional chemical agents include nerve, blister, blood, and choking agents. They are primarily designed for use against personnel and to contaminate terrain and material. Agents do not destroy material and structures, but make them unusable for periods of time because of chemical contaminant absorption. The duration of chemical agent effectiveness depends on weather conditions, dispersion methods, terrain conditions, physical properties, quantity used, type used (nerve, blood, blister), and whether the agent is persistent or nonpersistent.

3-18. Biological agents are categorized as disease-producing organisms (pathogens) and toxins. The time from exposure to maximum effects generally ranges from a few hours to several days. Biological agents have the potential to cover thousands of square kilometers. Infective doses can be provided with a very small volume of biological agent due to the organism's microscopic size, its ability to replicate in its host, its potential transmissibility, and the high levels of toxicity in comparison to traditional chemical agents. A biological attack is not likely to be identified until medical surveillance systems respond to patients presenting with clinical symptoms or until biological point detection systems provide a presumptive identification result that will likely be used to support detect-to-treat recommendations.

3-19. The effects of nuclear weapons are qualitatively different from biological or chemical weapons. Nuclear weapons effects are classified as residual and initial. Residual effects (such as fallout) are primarily of long-term concern. Initial effects occur in the immediate area shortly after detonation and are the most tactically significant since they cause personnel casualties and material damage within the immediate time span of any operation. The principal initial casualty-producing effects are blast, thermal radiation (burning), and ionizing radiation. The blast from nuclear bursts overturns and crushes equipment, collapses lungs, ruptures eardrums, hurls debris and personnel, and collapses positions and structures. Thermal radiation sets fire to combustible materials and causes flash blindness or burns in the eyes as well as personnel casualties from skin burns.

3-20. Ionizing radiation (an effect of both nuclear and radiological weapons) damages cells throughout the body. This radiation damage may cause the headaches, nausea, vomiting, and diarrhea generally called radiation sickness. The severity of radiation sickness depends on the extent of initial exposure. Radiation in the body is cumulative. Ionizing radiation is the dominant casualty-producing effect of low-yield tactical nuclear weapons.

3-21. Other initial effects of nuclear weapons may produce significant damage and casualties depending on the weapon type, yield, burst conditions, and the degree of personnel and equipment protection. EM pulse damages electrical and electronic equipment. It occurs at distances from the burst where other nuclear weapons effects produce little or no damage, and it lasts for less than a second after the burst. The pulse also damages vulnerable electrical and electronic equipment at ranges up to 5 kilometer for a 10-kiloton surface burst, and hundreds of kilometers for a similar high-altitude burst.

Note. See FM 3-11/MCWP 3-37.1, FM 3-11.4/MCWP 3-37.2/NTTP 3-11.27/AFTTP(I) 3-2.46, and JP 3-11 for additional information about CBRN threats and hazards.

MITIGATING WEAPONS EFFECTS

3-22. When planning the construction of fighting and protective positions or the hardening of existing facilities, many items must be taken into consideration. The terrain, weather, material availability, and the type or level of threat will dictate many of the designs that are used. The use of existing buildings in built-up areas, for instance, may furnish an increased level of survivability based on location and construction materials. In other circumstances, new construction will be undertaken that will require the integration of survivability measures. There are several common areas that must be considered in the design of survivability construction.

DIRECT-FIRE MITIGATION

3-23. Direct fire consists of projectiles which are aimed directly at the position or structure. These projectiles include the various kinetic energy projectiles and chemical energy projectiles. Good position location and camouflage and concealment measures (see chapter 6) will help to prevent position detection and effective engagement. In the event the position does become a target, proper survivability construction will mitigate the damage. The goal of direct-fire survivability construction is to provide a target surface that is thick enough (and therefore strong enough) for the given material, or that provides for an oblique impact of projectiles at other than a perpendicular angle to the structure. An oblique impact surface increases the apparent thickness of the structure and decreases the possibility of penetration. The potential for ricochet off a structure increases as the angle of impact from the perpendicular increases. Designers of protective structures should select the proper material and design exposed surfaces with the maximum angle from the perpendicular to the direction of fire. Also, a low structure silhouette design makes a structure harder to engage with direct fire. Providing projectile-resistant construction is referred to as a high level of protection in common security engineering practice as defined in Unified Facilities Criteria (UFC) 4-020-01. Hypervelocity projectiles pose significant challenge in survivability position design. The materials used must dissipate the projectile's energy and thus prevent total penetration. Shielding against direct-fire projectiles should initially stop or deform the projectiles to prevent or limit penetration.

3-24. Another technique used to mitigate direct-fire weapons effects is the use of predetonation screens, which can provide effective protection from rocket-propelled grenades (RPGs). These are solid screens placed between potential vantage points and the target that incoming rounds impact before impacting the target. In doing so, the rounds are predetonated, allowing their effects to dissipate between the screen and the target. Predetonation screens commonly are of wood slat or plywood construction. They may also serve as obscuration screens, which are addressed in chapter 6 of this manual. See paragraph 3-63 for a discussion of screens designed to predetonate RPGs and other munitions.

INDIRECT-FIRE MITIGATION

3-25. Indirect-fire weapons include mortars, rockets, missiles, artillery, and grenade launchers (in an indirect-fire role). In indirect fire, survivability from fragmentation requires measures similar to those needed to protect from direct-fire penetration. Protection against fragments from airburst artillery is provided by a thickness of shielding required to defeat a certain size shell fragment, supported by a roof structure adequate for the dead load of the shielding. Survivability construction may also be conducted to mitigate the effects of direct hits from various sizes of artillery mortar rounds and rockets.

3-26. Protection against direct impacts from indirect-fire weapons usually requires a significant amount of effort. These measures generally include some form of soil cover on the structure, and may be supplemented by a bursting layer of harder material such as stone or masonry rubble. Appendix D discusses the design of roof structures to defeat contact bursts of indirect-fire projectiles. (Contact the United States Army Corps of Engineers Reachback Operations Center [UROC] [see appendix B] for assistance with design of roof structure to defeat delay-fuze burst projectiles.) In all cases, great care in the design must be taken to ensure the safety of personnel occupying the structure.

3-27. Because roofs constructed to resist direct blast effects and fragmentation from indirect-fire rounds tend to be quite thick and heavy, an alternate approach is to provide a lightweight sacrificial roof at a short distance above a hardened roof to detonate the round at a standoff, thus minimizing the thickness of the hardened roof. In addition, walls and windows need protection against the fragmentation and blast effects of incoming rounds. See Graphic Training Aid (GTA) 90-01-018 for further guidance.

EXPLOSIVE HAZARD MITIGATION

3-28. The effect of EHs may be mitigated by several means. Proper training in the recognition of, and reaction to, EHs is the first line of defense against them. Reconnaissance and site selection to avoid potentially hazardous areas will help to reduce the chances of encountering EHs. The proper use of personal protective equipment, including the wearing of body armor and eye protection, and the use of armored vehicles will reduce the impact against personnel and equipment. Employing entry control points

(ECPs), and using explosive detection devices and military working dogs will reduce the chances that an IED or VBIED attack can occur on a base camp. In the event that an IED is employed, proper protective construction and standoff distances from facilities will mitigate the effects. Maintaining situational understanding of the threat, hardening structures, equipment, and personnel against attack, and employing security and route clearance techniques are essential to defeat the IED threat. FM 3-90.119/MCIP 3-17.01 contains doctrine on IED defeat operations.

3-29. Mines and UXO can be countered by many of the measures employed against IEDs. In addition, good information and intelligence about past conflicts in the AO and reconnaissance of possible hazard sites will reduce the chances that personnel may encounter them. Good planning in the selection of base camps will also avoid sites that may present significant mine and UXO hazards.

> ***Note.*** See FM 3-34.210/MCRP 3-17.2D for additional information on EH operations and FM 3-34.214/MCRP 3-17.7L for information on explosives and demolitions.

Chemical, Biological, Radiological, and Nuclear Threat and Hazard Mitigation

3-30. Survivability positions can enhance protection against CBRN threats and hazards. Certain vehicles and tent systems have built-in protection, generally in the form of overpressure systems that keep out contaminated air. In other cases, structures can be sealed against the in-flow of contaminants. Engineer assistance is also required in the construction of operational and deliberate decontamination sites. See FM 3-11.4/MCWP 3-37.2/NTTP 3-11.27/AFTTP(I) 3-2.46 and FM 3-11.5/MCWP 3-37.3/NTTP 3-11.26/AFTTP(I) 3-2.60 for more information on CBRN protection and CBRN decontamination.

3-31. For collective protection from biological agents, personnel may be housed inside a shelter with an efficient air filter system. Many buildings may be converted into temporary shelters if cracks are carefully sealed and a chemical and biological filter system with a ventilating mechanism is installed.

3-32. Nuclear weapons survivability includes dispersion of protective positions within a suspected target area. Deep-covered positions will minimize the danger from blast and thermal radiation. Personnel should wear complete uniforms with hands, face, and neck covered. Ionizing radiation is minimized by avoiding the radioactive fallout. Facilities can be hardened against blast effects, and fire prevention techniques can be integrated. In addition, electronic equipment can be protected against some EM pulse effects by turning off the systems and disconnecting antennas and peripheral devices. See FM 3-11.4/MCWP 3-37.2/NTTP 3-11.27/AFTTP(I) 3-2.46 and FM 3-11.5/MCWP 3-37.3/NTTP 3-11.26/AFTTP(I) 3-2.60 for more information on CBRN protection and CBRN decontamination.

3-33. Increasing the amount of earth cover significantly improves protection from radiation. An open fighting position blocks most of the line-of-sight radiation and allows only a fraction of scattered radiation to enter. Each added 6-inch thickness of overhead earth cover reduces the scattered radiation by a factor of 2. Adding layers of sandbags also improves shielding. Each layer of sandbags, if filled with sand or compacted clay, reduces the transmitted radiation by a factor of 2. Sand or compacted clay gives better radiation shielding than earth because it is denser. Each layer of sand- or clay-filled sandbags can give up to 66 percent more radiation protection than the same thickness of soil or soil-filled sandbags. (See tables II-3 and II-4 in FM 3-11.4/MCWP 3-37.2/NTTP 3-11.27/AFTTP(I) 3-2.46.)

> ***Note.*** For additional information on cover (and other protection) from CBRN agents and weapons, see FM 3-11.3/MCRP 3-37.2A/NTTP 3-11.25/AFTTP(I) 3-2.56 and FM 3-11.4/MCWP 3-37.2/NTTP 3-11.27/AFTTP(I) 3-2.46.

Standoff

3-34. Standoff pertains primarily to facility protection. Standoff provides distance between the existing facility and the location from which the facility could be attacked. If the threat is commonly using explosive devices to attack friendly facilities, the effects of the explosion on a facility will decrease

exponentially with distance. Standoff must be considered when hardening any facility. This becomes especially critical to defeat the blast effect of VBIEDs. For more information about standoff, see GTA 90-01-011, UFC 4-010-01, and UFC 4-020-01.

COMPARTMENTALIZATION

3-35. In areas where there are high concentrations of Soldiers/Marines—such as dining facilities, sleeping quarters, fitness centers, and recreation centers—survivability is greatly increased by compartmentalization. Compartmentalization refers to dividing a large, heavily populated facility into smaller components through the use of ballistic resistant walls. These walls can be placed both inside and outside a facility, and in the event a fragmenting weapon detonates near or inside the facility the fragmentation effects can be contained. Fragmentation from the exploding munitions and flying debris from construction materials caused by the blast inflict the most injury, however, special attention must be paid to ensure that the protective walls themselves do not become a hazard. They should be properly designed to minimize motion generated by the blast. This is especially true when the compartmentalization walls are inside the structure with personnel in close proximity. For more information about compartmentalization see GTA 90-01-011.

INFORMATION SYSTEMS SHIELDING

3-36. Considerations for design of information systems shielding are a complex topic and will seldom apply to initial facilities protection designs. Grounding, bonding, and shielding of telecommunications-electronics facilities are approached from a total system concept, which comprises four basic subsystems according to current Department of Defense (DOD) guidance (see Military Handbook 419A). These subsystems include—

- An earth electrode subsystem.
- A lightning protection subsystem.
- A fault protection subsystem.
- A signal reference subsystem.

MATERIALS AND TECHNIQUES

3-37. This section discusses various materials and techniques for providing or improving cover. These materials and techniques can be employed in constructing fighting positions (which are addressed in more detail in chapter 4) or protective positions (addressed in more detail in chapter 5) or in hardening facilities.

MATERIALS

3-38. Deployed forces will rely on the most abundant local materials and the usually available materials provided through routine supply channels. Materials such as soil, steel, concrete, rock, wood, bricks, and masonry provide shielding and protection against penetration of both projectiles and fragments. Table 3-1 and tables 3-2, 3-3, 3-4, and 3-5, pages 3-8 through 3-11, contain shielding requirements of various materials to protect against direct hits by direct-fire projectiles. (If additional data is needed, contact the UROC [see appendix B].)

Table 3-1. Material thickness (in inches) required to protect against direct hits by direct-fire projectiles

Material	Small Caliber (5.56-mm) Fire at 100 Yards	Small Caliber and Machine Gun (7.62-mm) Fire[1] at 100 Yards	Small Caliber and Machine Gun (12.7-mm) Fire[1] at 100 Yards	Antitank Rifle (76-mm) Fire at 100 Yards	20-mm Antitank Fire at 200 Yards	37-mm Antitank Fire at 400 Yards	50-mm Antitank Fire at 400 Yards	75-mm Direct-fire at 500 to 1,000 Yards	Remarks
Solid walls									
Solid clay brick masonry	9	16	NR	24	30	60	NR	NR	None
Concrete masonry unit (grout filled)	9	16	NR	NR	NR	NR	NR	NR	None
Steel	7/16	5/8	1 3/8	NR	NR	NR	NR	NR	None
Concrete, reinforced	8	12	22	12	18	36	42	48	Structurally reinforced with steel.
Stone masonry	8	12	22	18	30	42	54	60	Values are guides only.
Timber	NR	NR	36	60	NR	NR	NR	NR	Values are guides only.
Wood	NR	NR	24	36	48	NR	NR	NR	Values are guides only.
Walls of loose material between boards									
Brick rubble	NR	NR	12	24	30	60	72	NR	None
Clay, dry	NR	NR	36	48	NR	NR	NR	NR	Add 100% to thickness if wet.
Gravel/ small crushed rock	NR	NR	12	24	30	60	72	NR	None
Loam, dry	NR	NR	24	36	48	NR	NR	NR	Add 50% to thickness if wet.
Sand, dry	NR	NR	12	24	30	60	72	NR	Add 100% to thickness if wet.
Sandbags filled with—									
Brick rubble	NR	NR	20	30	30	60	70	NR	None
Clay, dry	NR	NR	40	60	NR	NR	NR	NR	Add 100% to thickness if wet.
Gravel/small crushed rock	NR	NR	20	30	30	60	70	NR	None
Loam, dry	NR	NR	30	50	60	NR	NR	NR	Add 50% to thickness if wet.
Sand, dry	NR	NR	20	30	30	60	70	NR	Add 100% to thickness if wet.

Table 3-1. Material thickness (in inches) required to protect against direct hits by direct-fire projectiles (continued)

Material	Small Caliber (5.56-mm) Fire at 100 Yards	Small Caliber and Machine Gun (7.62-mm) Fire[1] at 100 Yards	Small Caliber and Machine Gun (12.7-mm) Fire[1] at 100 Yards	Antitank Rifle (76-mm) Fire at 100 Yards	20-mm Antitank Fire at 200 Yards	37-mm Antitank Fire at 400 Yards	50-mm Antitank Fire at 400 Yards	75-mm Direct-fire at 500 to 1,000 Yards	Remarks
Loose parapets of—									
Clay	NR	NR	42	60	NR	NR	NR	NR	Add 100% to thickness if wet.
Loam	NR	NR	36	48	60	NR	NR	NR	Add 50% to thickness if wet.
Sand	NR	NR	24	36	48	NR	NR	NR	Add 100% to thickness if wet.
Snow and ice									
Frozen snow	NR	NR	80	80	NR	NR	NR	NR	None
Frozen soil	NR	NR	24	24	NR	NR	NR	NR	None
Icecrete (ice + aggregate)	NR	NR	18	18	NR	NR	NR	NR	None
Tamped snow	NR	NR	72	72	NR	NR	NR	NR	None
Unpacked snow	NR	NR	180	180	NR	NR	NR	NR	None

Note.
Except where indicated, protective thicknesses are for a single shot only. Where weapons place five or six fire projectiles in the same area, the required protective thickness is about twice that indicated.
[1] One burst of five shots.
Legend:
mm – millimeter NR – not recommended

Table 3-2. Small arms protection characteristics of various materials

	Small Arms Projectile (at Range of)[1]								
Material[1]	***9-mm M882 Ball[2]***	***5.56-mm x 45 M855 Ball[2]***	***7.62-mm x 39 M67 Ball***	***7.62-mm x 54R Type LPS Ball***	***7.62-mm x 51 M80 Ball[2]***	***7.62-mm x 51 M61 AP***	***.50-cal M2 & M33 Ball***	***.50-cal AP M2 & API-T M20***	***14.5-mm API***
Mild Steel Plate Thickness (in inches)	1/4 (50 m)	11/16 (100 m)	7/16 (10 m)	13/16 (10 m)	9/16 (–)	13/16 (–)	1-1/4 (–)	–	–
Armor Steel Plate Thickness (in inches)	3/16 (50 m)	11/16 (100 m)	–	–	7/16 (–)	11/16 (–)	1 (–)	1-1/4 (100 m)	–

Table 3-2. Small arms protection characteristics of various materials (continued)

Material	9-mm M882 Ball[2]	5.56-mm x 45 M855 Ball[2]	7.62-mm x 39 M67 Ball	7.62-mm x 54R Type LPS Ball	7.62-mm x 51 M80 Ball[2]	7.62-mm x 51 M61 AP	.50-cal M2 & M33 Ball	.50-cal AP M2 & API-T M20	14.5-mm API
Concrete Thickness (in inches)	2 (50 m)	5 (200 m)	–	–	4 (–)	6-1/2 (–)	12 (100 m)	18 (200 m)	–
Wythes of Nominal 4-in Thick Brick	1 (50 m)	2 (100 m)	1 (23 m)	2 (23 m)	2 (–)	2 (–)	6 (100 m)	–	–
Layers of Nominal 9/16-in Thick E-glass, Ballistic Grade[3]	1 (muzzle velocity)	3 (muzzle velocity)	2 (muzzle velocity)	–	3 (muzzle velocity)	7 (muzzle velocity)	12 (muzzle velocity)	14 (muzzle velocity)	–
Layers of Nominal 8 in - 10 in Thick Sandbags	1 (50 m)	2 (100 m)	2* (100 m)	2* (100 m)	2 (100 m)	2 (100 m)	3 (100 m)	3 (200 m)	3 (200 m)
8-in Thick Hollow CMU	Protects (–)	Fails (19 m)	Fails (19 m)	Fails* (19 m)	Fails (100 m)	Fails* (–)	Fails (19 m)	Fails* (19 m)	Fails* (19 m)
8-in Thick Grout-Filled CMU	Protects* (–)	Protects (100 m)	Protects (23 m)	Protects (23 m)	Protects (–)	Protects (–)	Fails* (100 m)	Fails* (200 m)	Fails* (200 m)
4-in Brick/2-in Air/8-in Hollow CMU	Protects* (–)	Protects* (23 m)	Protects (23 m)	Protects (23 m)	Protects (23 m)	Protects (23 m)	Fails* (100 m)	Fails* (200 m)	Fails* (200 m)
Sand and Steel Plates[4]	–	–	–	10 in of sand + 0.4 in mild steel (30 m)	–	10 in of sand + 0.4 in mild steel (30 m)	–	10 in of sand + 0.8 in mild steel	20 in of sand + 0.4 in mild steel

Note.
Table taken from Graphic Training Aid 90-01-011, *Joint Forward Operations Base (JFOB) Protection Handbook (6th edition),* and revised with additional information provided by the United States Army Engineer Research and Development Center. Table data based on single shots. Multiple shots in or near the same area may penetrate. A dash indicates no data.
[1] All thicknesses are in inches and all ranges are in meters.
[2] North Atlantic Treaty Organization small arms projectile.
[3] National stock number 9340-01-533-3758.
[4] Other sand-filled containers of equal thickness can be used. Data is for dry sand. For wet sand, use twice the indicated thickness.
* Inferred from other data.

Legend:
AP – armor piercing
API – armor piercing incendiary
API-T – armor piercing incendiary-tracer
cal – caliber
CMU – concrete masonry unit
in – inch
m – meter
mm – millimeter

Table 3-3. Material thickness (in inches) required to protect against direct-fire high-explosive shaped charge

Material	***73-mm RCLR***	***82-mm RCLR***	***85-mm RPG-7***	***107-mm RCLR***	***120-mm Sagger (ATGM)***
Aluminum	36	24	30	36	36
Concrete	36	24	30	36	36
Granite	30	18	24	30	30
Rock	36	24	24	36	36
Snow, packed	156	156	156	—	—
Soil	100	66	78	96	96
Soil, frozen	50	33	39	48	48
Steel	24	14	18	24	24
Wood, dry	100	72	90	108	108
Wood, green	60	36	48	60	66

Note.

Thicknesses assume perpendicular impact. A dash indicates no data.

Legend:

ATGM – antitank guided missile RCLR – recoilless rifle

mm – millimeter RPG – rocket-propelled grenade

Table 3-4. Material thickness required to protect against a direct hit with an RPG with HEAT/thermobaric warhead

Material	***Required Thickness for Protection in Inches (Millimeters)***[1, 2]	
	Minimum	***Recommended***
Armored steel	26.1 (663)	33.1 (840)
Mild steel	32.6 (828.75)	41.3 (1050)
Aluminum	45.7 (1160.25)	57.9 (1470)
Lead	23.0 (583.44)	29.1 (739.2)
Copper	24.5 (623.22)	31.1 (789.6)
Concrete	47.5 (1206.66)	60.2 (1528.8)
Earth	64.5 (1637.61)	81.7 (2074.8)
Granite	43.9 (1113.84)	55.6 (1411.2)
Rock	45.7 (1160.25)	57.9 (1470)
Water	73.1 (1856.4)	92.6 (2352)
Green wood	77.5 (1969.11)	98.2 (2494.8)

Note.

Table was developed using information provided by Unified Facilities Criteria 3-340-01, the United States Army Research and Development Center, and the National Ground Intelligence Center. Calculations assume an RPG-7 with an 85-millimeter shaped charge warhead detonating in direct contact with protective material.

[1] Thicknesses listed in the “Minimum” column provide protection against lethal injury, but may not protect against non-lethal injury. To achieve maximum protection for personnel, use thickness listed in the “Recommended” column.

[2] The use of predetonation screens at an appropriate standoff distance can enable smaller thicknesses to provide the same level of protection. For assistance with determining appropriate predetonation screen designs and standoff distances, contact the United States Army Corps of Engineers Reachback Operations Center.

Legend:

HEAT – high explosive antitank RPG – rocket propelled grenade

Table 3-5. Material thickness (in inches) required to protect against indirect-fire fragmentation and blast exploding 50 feet away

Material	*Mortars 82 mm*	*Mortars 120 mm*	*Rockets 122 mm*	*HE Shells 122 mm*	*HE Shells 152 mm*	*Bombs 100 lb*	*Bombs 250 lb*	*Bombs 500 lb*	*Bombs 1,000 lb*
Solid walls									
Brick masonry	4	6	6	6	8	8	10	13	17
Concrete	4	5	5	5	6	8	10	15	18
Concrete, reinforced	3	4	4	4	5	7	9	12	15
Timber	8	12	12	12	14	15	18	24	30
Walls of loose material between boards									
Brick rubble	9	12	12	12	12	18	24	28	30
Soil[1]	12	12	12	12	16	24	30	NR	NR
Gravel, small stones	9	12	12	12	12	18	24	28	30
Sandbags filled with—									
Brick rubble	10	18	18	18	20	20	20	30	40
Clay[1]	10	18	18	18	20	30	40	40	50
Gravel, small stones, soil	10	18	18	18	20	20	20	30	40
Sand[1]	8	16	16	16	18	30	30	40	40
Loose parapets of—									
Clay[1]	12	20	20	20	30	36	48	60	NR
Sand[1]	10	18	18	18	24	24	36	36	48
Snow									
Tamped	60	60	60	60	60	NR	NR	NR	NR
Unpacked	60	60	60	60	60	NR	NR	NR	NR

[1] Double the values if material is saturated.

Legend:
HE – high explosive lb – pound mm – millimeter NR – not recommended

3-39. Soil is often used for protection against the penetrating effects of projectiles. There are a few general rules about the ability of soil to protect against such penetration: coarse-grained and well-graded soils protect better than fine-grained soils; protection increases with the level of soil compaction; and protection decreases with increased soil moisture content.

3-40. Steel is a commonly used material to protect against penetration by projectiles and projectile fragments. Many field expedient types of steel can be used in construction, such as culvert sections, steel drums, and U-shaped pickets. Steel may be used for shielding, while steel structures such as culverts may be used as expedient protective shelters (when covered with soil or other protection). Containers express (CONEX) may also be used, both above- and belowground, as bunkers and protective positions. When using steel for shielding, the most effective application is to use plate steel. Place multiple members in contact with each other and add the thicknesses of the individual members until they meet or exceed the thicknesses in table 3-1, page 3-7. Ensure that the material is thick enough to defeat the threat that it is designed for. Steel used on the surface of a survivability position, that is not thick enough to defeat the threat, will provide an additional source of fragmentation that can kill or injure personnel.

3-41. Concrete is also very effective for shielding, but should not be used without steel reinforcement. A potential consequence of concrete penetration is spalling. If a projectile partially penetrates concrete shielding, particles and chunks of concrete often break or scab off the back of the shield at the time of impact. These particles can kill when broken loose, but they are commonly not lethal. The entries for concrete in table 3-1 include the thicknesses of concrete to prevent spall. Another option is to place sandbags up against the inner face of a wall that is not thick enough to prevent spall. The sandbags will

minimize the hazard associated with the spalling concrete. Other materials such as wood or steel can also be used to minimize spall effects. Concrete provides excellent protection against ionizing and thermal radiation. Prefabricated concrete barriers are used to protect structures against observation and attack and to provide standoff to mitigate the effects of explosive detonations. Prefabricated concrete structures are also commonly used as protective shelters in base camps and other contingency construction.

3-42. Rock, especially in layers, can protect against penetration by projectiles and projectile fragments. The more dense the rock properties, the better the protective qualities. Sandstone is less effective than basalt, shale, or gneiss. Rock is often used as a bursting layer in overhead cover.

3-43. Wood is often used for structural support in a survivability position. The low density and relatively low compressive strength of wood limits its ability to protect against penetration by projectiles and projectile fragments. Greater thicknesses of wood than of soil are needed for protection from penetration. The greater the thickness, the better the protection; but quantities are usually limited. Wood provides poor protection from ionizing and thermal radiation. Because of its low ignition point, wood is easily destroyed by fire from thermal radiation. In some areas of the world, wood construction materials are not readily available. Wood can also be subject to damage from pests.

3-44. Brick and masonry can be effective for shielding. They provide protection similar to that of concrete, but are less effective due to their lower compressive strengths. Generally, solid masonry or masonry with its voids filled with grout should be used for shielding against projectiles. Note also that masonry can exhibit spalling behavior similar to concrete as well; therefore, it should be treated similarly to concrete as discussed above. Ionizing and thermal radiation protection by brick and masonry are 1.5 times as effective as for soil. This characteristic is due to a higher compressive strength and hardness properties in brick and masonry. Since density determines the degree of protection against initial radiation, unreinforced brick and masonry are not as effective as concrete for penetration protection.

3-45. Sandbags can be used in a number of ways. They can be filled with soil, but should have minimal rock to minimize spalling when a sandbag is hit. There are also a number of techniques for quickly getting sandbags filled, such as the palletized load system's concrete mobile chute and the small emplacement excavator attachment. Sandbagging is the least preferred soil construction method because it is the most costly in terms of materials and labor. If layers are not interlocked, sandbags will not be useful. Structures constructed of sandbags have a life of six months to a maximum of one year. The effects of sun and other weather considerations, and the type of sandbags used, will have an effect on their longevity.

3-46. One of the most common mistakes made in building sandbag structures is inadequate overhead support for the overhead sandbag cover. Ensure that such support is correctly designed. Figure 3-1 depicts an example of a poor sandbag technique: the sandbags are improperly filled, not interlocked and, therefore, do not form effective protection.

Figure 3-1. Poor sandbag technique example

3-47. Figure 3-2 depicts a concrete shelter with sandbags being used to provide an additional level of protection. In this example, the sandbags are compact and properly supported by the bunker structure. The sandbags have been used to reduce the amount of fragmentation that can enter the bunker. As shown, the sandbags are interlocked, thus maximizing their overall effectiveness.

Figure 3-2. Proper sandbag technique example

3-48. Soil-filled containers are a common option for survivability construction. Soil-filled containers are easy to emplace, come in various sizes, are stackable to different heights, and may be used to protect existing structures or may be configured as a structure themselves. They typically come in multiple sizes that also allow for circumstances that require a taller soil-filled container, such as for aircraft revetments. Soil-filled containers consist of a fabric lined metal framework that interconnects and is then filled with soil. They may be used for walls and also for overhead protection, as long as the supporting structure is adequate. When building with soil-filled containers, ensure that the ground is level and well compacted, and that provisions are made for water to drain out of the enclosed area.

STRUCTURAL COMPONENTS

3-49. The structure of a protective position depends on the weapon or weapon effect it is designed to defeat. All fighting and protective positions have some configuration of floor, walls, and roof designed to protect material and/or occupants. The floor, walls, and roof support the shielding discussed earlier, or may in themselves make up that shielding. These components must also resist blast and ground shock effects from the detonation of HE rounds, which place greater stress on the structure than the weight of the components and the shielding. Designers must make structural components of the positions stronger, larger, and/or more numerous to defeat blast and ground shock.

Floors

3-50. Fighting and protective position floors are made from almost any material but require resistance to weathering, wear, and must provide trafficability. Soil is most often used, yet is the least resistant to water damage and rutting from foot and vehicle traffic. Wood pallets, or other field-available materials, are often cut to fit floor areas. Whenever possible, integrate drainage into the design of the structure. At a minimum, anything that will help keep personnel and equipment out of the mud and water, such as wooden floors, pallets, or crushed rock will improve the position. Ensure that aboveground structures, such as enclosed areas protected by soil berms, sand bag walls, and soil-filled containers, have a way for water to drain out of the area.

Walls

3-51. Walls of fighting and protective positions include two basic types: belowground (earth or revetted earth) and aboveground. Belowground walls are made of the in-place soil remaining after excavation of the position. This soil may need revetment or support—depending on the soil properties and the depth of cut. A revetment is (usually) a mound or wall of earth, masonry, timber, sandbags, or other suitable material erected as a protection for aircraft against small arms or artillery fire, bomb splinters, or blast. When used to support roof structures, earth walls must support the roof at points no less than one-fourth the depth of cutout from the edges of excavation to prevent cave-in. Above-ground walls are normally constructed for shielding from direct fire and fragments. They are usually built of revetted earth, sandbags, concrete, or other materials. When constructed to a thickness adequate for shielding from projectiles and projectile fragments, they are thick and stable enough for roof support.

Roofs

3-52. Roofs of protective positions are easily designed to support earth cover for shielding from fragments and small caliber direct fire. However, contact burst protection requires much stronger roof structures and, therefore, careful design. See appendix D for a detailed discussion of roof design including roofs required to defeat contact burst projectiles. For information about roofs that protect against delay-fuze burst projectiles, contact the UROC (see appendix B). Roofs for support of earth cover shielding are constructed of almost any material that is usually used as beams or stringers and sheathing. See paragraph 3-60 for information about predetonation roofs.

PROTECTIVE WALLS

3-53. While some walls only provide support for the structure or fulfill some other purpose, protective walls provide protection against the effects of fires. They are constructed to satisfy a variety of conditions such as weather, topographical, tactical and other military requirements. The walls range from simple ones, constructed with hand tools, to more complicated walls requiring specialized engineering and equipment capabilities.

3-54. Protection provided by walls is restricted to stopping fragment and blast effects from near-miss explosions of mortar, rocket, or artillery shells; some direct-fire protection is also provided. Overhead cover is not practical due to the size of the position surrounded by the walls. In some cases, modification of the designs shown in the following graphics will increase nuclear protection. The wall's effectiveness substantially increases by locating it in adequately defended areas. The walls need close integration with other forms of protection such as dispersion, concealment, and adjacent fighting positions. The protective walls should have the minimum inside area required to perform operational duties. Further, the wall’s height should be at least equal to the height of the equipment being protected. See GTA 90-01-011 for additional information about protective walls (which that publication refers to as sidewall protection).

Earth Walls and Berms

3-55. Earth walls are constructed entirely of compacted earth fill and are used for protection against blast and shell fragments, to contain liquid material spills, and to stop or channel vehicle and pedestrian movement. Berms are earth mounds comprised of uncompacted fill and are used for the same functions as earth walls. Berms are generally easier and faster to build and require fewer resources. The sides should have a 1:1 slope, so a large area is required. Earth walls and berms (see figure 3-3) must be maintained to keep their protective capability, particularly in areas with high wind or excessive rainfall.

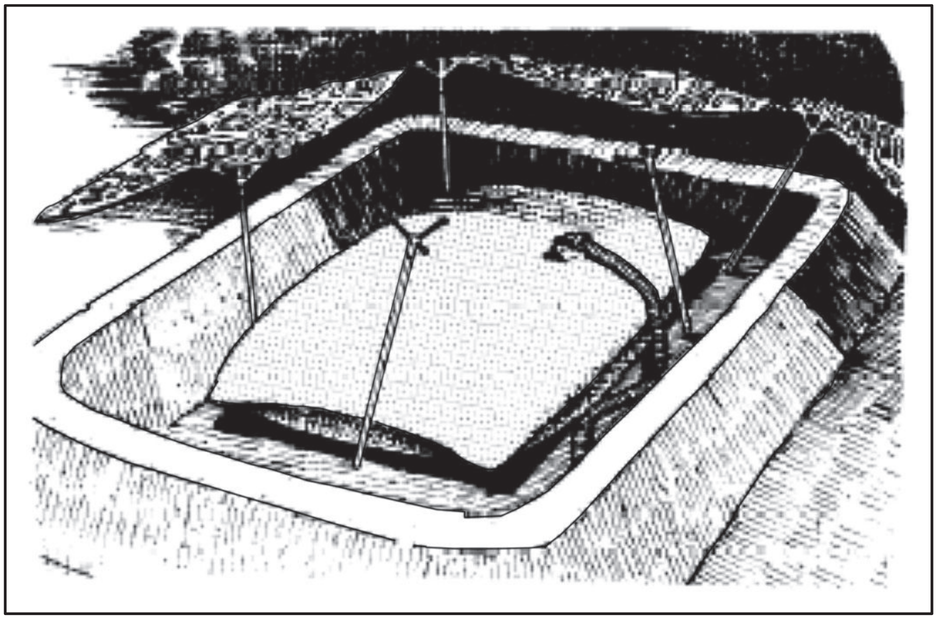

Figure 3-3. Earth berms

Revetments

3-56. Revetments are walls constructed of concrete, timber, sandbags, soil-filled containers, or other suitable materials that may be used to support earth walls and berms, or as stand-alone barriers designed to stop fragments, reduce blast effects, function as vehicle and pedestrian barriers, provide standoff from facilities and critical targets, and channel vehicle and pedestrian traffic. Figure 3-4 and figure 3-5, page 3-16, provide examples of revetments.

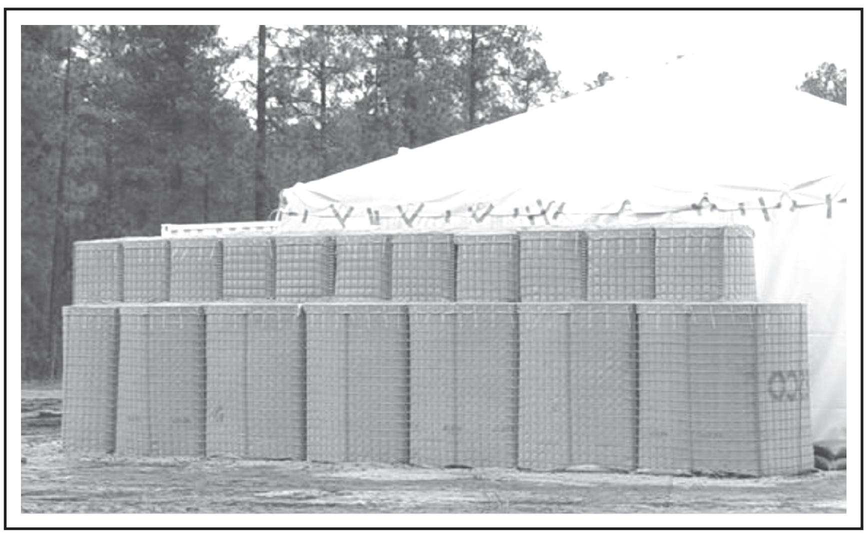

Figure 3-4. Soil-filled containers used as protective perimeter walls

Figure 3-5. Metal revetment walls used as blast protection

Earth Walls with Revetments

3-57. An earth wall with a revetment is a wall constructed of soil placed at a 1:1 slope against a revetment. Normally, the revetment is located on the inside of the wall with the revetment as close to the equipment being protected as possible. The wall's height should be at least equal to the height of the equipment being protected. See figure 3-6.

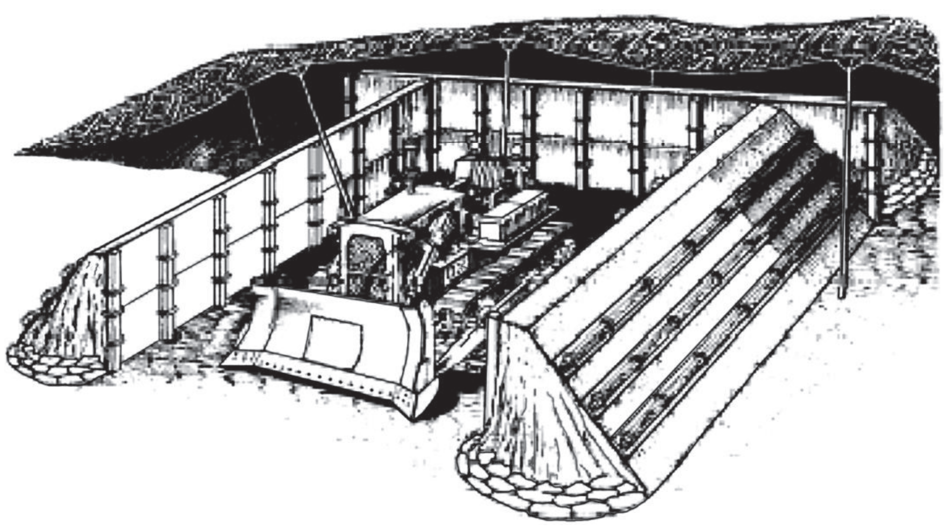

Figure 3-6. Earth walls with revetment

Soil Bin Walls with Revetment

3-58. Soil bin walls are constructed by placing compacted soil between two revetments. This is extremely effective and may be used in various ways. When compartmentalizing high troop concentration areas, soil

bin walls have proven effective in protecting personnel and equipment. Many materials are available to construct the revetments, including plywood, corrugated metal sheeting, and prefabricated metal revetments. Soil thickness should be a minimum of 1 foot, with 2 feet desired. They are proven to defeat artillery, mortar, and rocket shell fragments exploding as close as 5 feet from the walls. See figure 3-7.

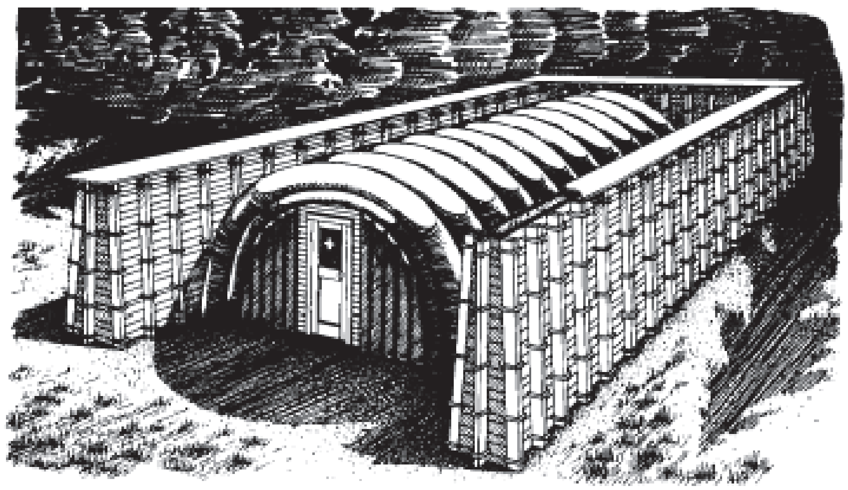

Figure 3-7. Soil bin walls with revetment

Soil-filled Container Revetments

3-59. Soil-filled container revetments are quickly constructed and can provide excellent cover for various types of equipment and resources. Additional hardening can be added by constructing overhead cover and predetonation roofs in conjunction with the revetments. For additional information on soil-filled container revetments see GTA 90-01-011.

ADDITIONAL CONSTRUCTION

Predetonation Roofs

3-60. Predetonation roofs (see figure 3-8, page 3-18) are sacrificial layers built over existing roofs to cause detonation of indirect-fire munitions before reaching the permanent structure. A variety of materials (see tables 3-6 and 3-7, pages 3-18 and 3-19) can be used to construct these systems but must be properly chosen based on the fuzing characteristics of the threat weapon. Predetonation roofs are intended to detonate the munitions and provide increased standoff to minimize the blast effect. These roofs must be supported by structure capable of supporting the weight of the structure itself (static load) and the force of the detonation and other moving or changing forces (dynamic loads); proper standoff is determined by threat analysis. (Contact the UROC [see appendix B] for assistance with determining proper standoff.) Additional measures must be taken to stop the fragmentation hazards generated during the detonation. A more substantial shielding layer is typically used.

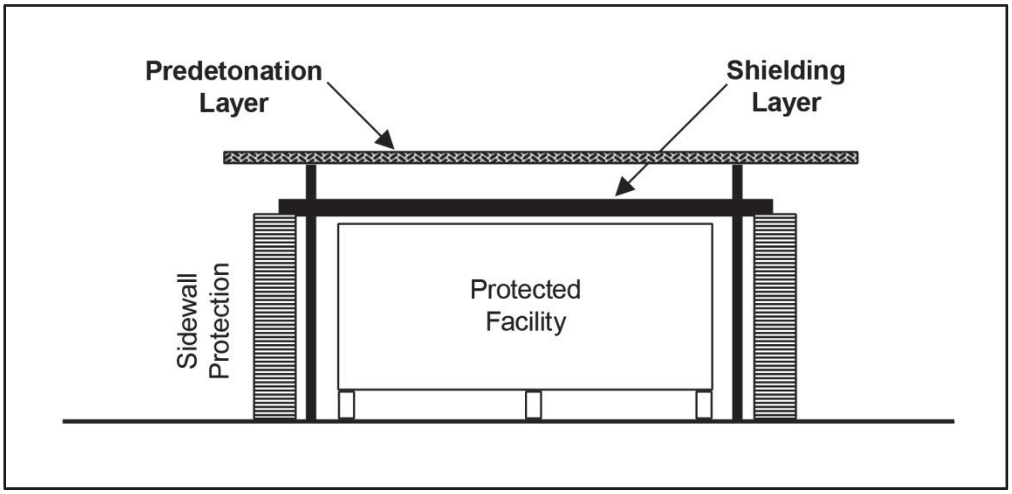

Figure 3-8. Predetonation and shielding layers

Table 3-6. Recommended material options for predetonation layers

Predetonation Layer Material	***60-mm Mortar***	***82-mm Mortar***	***120-mm Mortar***	***107-mm Rocket***	***122-mm Rocket***
1 layer of ballistic E-glass	–	Yes	–	–	
22-gauge corrugated steel	Yes	Yes	No	–	Yes
19 - 20 gauge steel deck	–	Yes	–	Yes	–
½-inch cement board	Yes	Yes	No	–	Yes[6]
½-inch OSB	Yes[5]	Yes	No	–	Yes
½-inch plywood	Yes	Yes	Yes	–	Yes[4]
¾-inch plywood[1]	Yes	Yes	Yes	Yes	–
4-inch sandwich panel (sheet steel/foam/sheet steel)[2]	Yes	Yes	Yes[7]	–	–
¼-inch steel plate[3]	–	Yes	Yes	–	–

Note.

The table source is Graphic Training Aid 90-01-011, *Joint Forward Operations Base (JFOB) Protection Handbook (6th edition)*.

The table is based on live-fire tests. "Yes" indicates round detonated, "No" indicates poor or no detonation, and a dash indicates no data.

[1] The recommendation for the 60-mm mortar is based on tests against ½-inch plywood.

[2] A 2-inch thick panel was also tested but was not as consistent as the 4-inch panel in detonating mortar rounds. The recommendation for the 82-mm mortar is based on results of the 2-inch panel.

[3] Potentially hazardous secondary debris may be generated when the 120-mm mortar predetonates on steel plate.

[4] Based on the performance of ½-inch OSB.

[5] Based on the performance of ½-inch plywood.

[6] Based on the performance of ⅜-inch cement board.

[7] Based on tests where 2 of 3 rounds detonated.

Legend:

mm – millimeter   OSB – oriented strand board

Table 3-7. Material options for shielding layers

Shielding Layer Material	*60-mm Mortar*	*82-mm Mortar*	*120-mm Mortar*	*107-mm Rocket*[3]
3½ inches of sand	Yes	Yes	Yes[1]	Yes
¼-inch steel plate	Yes	Yes	No	No
⅝-inch steel plate	Yes	Yes	Yes	Yes
2 layers of ballistic E-glass	Yes	Yes	No	No
3 layers of ballistic E-glass[2]	Yes	Yes	Yes	Yes

Note.
The table source is Graphic Training Aid 90-01-011, *Joint Forward Operations Base (JFOB) Protection Handbook (6th edition)*.
"Yes" indicates fragments were stopped, "No" indicates fragments penetrated the material.
[1] Experiments show that 3½ inches of sand will stop approximately 90 percent of the fragments and 7 inches will stop nearly 100 percent of the fragments.
[2] Assumes a 5 foot minimum space between predetonation and shielding layers. For spacing between 3½ feet and 5 feet, use four layers. For spacing between 2½ feet and 3½ feet, use five layers.
[3] Based on 120-mm mortar results.
Legend:
mm – millimeter

3-61. Currently, plywood and structural insulated panels are the most effective materials in causing detonation of most threat munitions. Solid predetonating roofs must be used instead of materials like chain link fence fabric because the different fuzing mechanisms of the mortar rounds require solid surfaces to trigger them. Predetonation roofs can be used on temporary structures and permanent fixed facilities as long as additional precautions are taken to address the fragmentation effects. (For additional information about predetonation roofs, see GTA 90-01-011.)

Predetonation Screens

3-62. Predetonation (or triggering) screens (see figure 3-9) increase survivability from direct-fire weapons with explosive warheads and from indirect-fire rounds with relatively low trajectories. Screens are similar in function to the predetonation roof, but are constructed vertically. A properly designed support structure must be provided to hold the material at a height equal to or greater than the elevation of the protected asset. To be effective at predetonating most direct-fire weapons with explosive warheads, the predetonation screen must be built using a solid material such as wood. Soil-filled containers and walls also can effectively predetonate direct-fire rounds. Mitigating the effects of explosive threats that include fragmentation hazards requires the addition of a blast or fragmentation barrier.

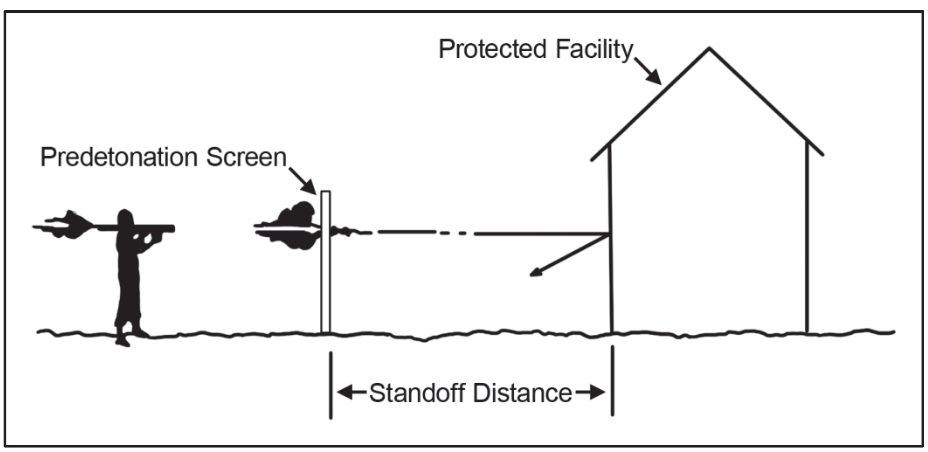

Figure 3-9. Predetonation screen

3-63. Predetonation screens are separately built or added on to existing structures and used to activate the fuze of an incoming shell or projectile at a designated standoff distance from the structure. See figures 3-10 and 3-11. A variety of materials can be used to construct the screen, which is intended to cause a detonation at an increased standoff to minimize blast effects. Properly designed triggering screens are particularly effective against superquick fuzes because the detonation will occur immediately upon impact. However, if the fuze is capable of delay settings, the additional flight after initiating on the triggering screen must be accounted for when specifying the standoff at which the screen will be placed. Delay shells require more material to both limit penetration and activate the fuze.

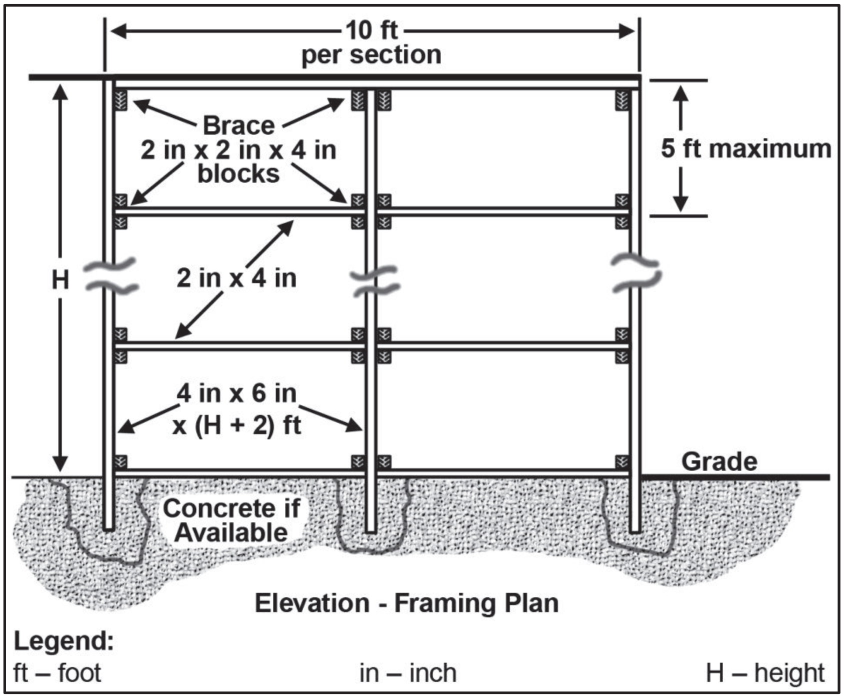

Figure 3-10. Typical standoff framing with dimensioned wood predetonation screen (frontal)

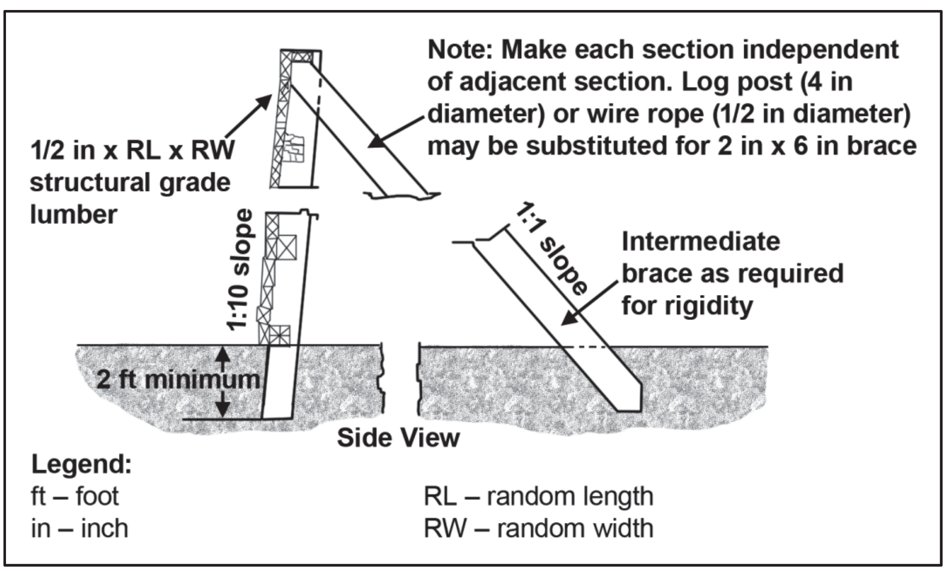

Figure 3-11. Typical standoff framing with dimensioned wood predetonation screen (side view)

3-64. Incoming projectiles with superquick fuzes are defeated at a standoff distance with several types of predetonation materials. Table 3-8 lists the thicknesses associated with various facing material for the construction of predetonation screens, but such screens only detonate the incoming shell—they do not defeat fragments from the shell. Table 3-9 provides the requirement thicknesses for each of the materials associated with the wall used to absorb the resulting fragments created by the predetonation screen's activation of superquick fuzes. Collectively the predetonation screen and the associated wall (at a 10-foot standoff) are designed to defeat incoming projectiles with superquick fuzes. Contact the UROC (see appendix B) for additional information about materials and techniques for predetonation screens and assistance with determining proper standoff.

Table 3-8. Predetonation screen facing material requirements

Material	***Triggering Requirements*** [1]
Plywood, dimensioned timber	2 ½-inch thickness
Soil in sandbags with plywood or metal facing	2-inch thickness (24-gauge sheet metal)
Structured steel (corrugated metal)	1/4-inch thickness
Tree limbs	2-inch diameter
Ammunition crates	1 layer (1-inch thick wood)
Snow	3 feet

[1] For detonating projectiles up to and including 120-millimeter mortar, rocket, and artillery shells. For information about triggering requirements for other projectiles contact the United States Army Corps of Engineers Reachback Operations Center.

Table 3-9. Protective wall material thickness (in inches) at 10 foot standoff from predetonation screen

Material	***Incoming Shell Size*** [1]		
	82 mm	***120 mm***	***122 mm***
Soil	10	18	18
Soil, frozen	5	9	9
Sand	8	16	16
Clay	10	18	18
Steel	½	1	1
Wood (fir)	5	14	14
Concrete	4	6	6
Snow	60	80	80

[1] For information about wall material thicknesses for other projectiles contact the United States Army Corps of Engineers Reachback Operations Center.

Legend:

mm – millimeter

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Chapter 4
Fighting Positions

Fighting positions provide cover and (often) camouflage and concealment for personnel and physical assets. At the same time, fighting positions must allow Soldiers/Marines and their weapon systems to engage and destroy enemy forces from the position. Fighting positions include individual and crew-served weapon fighting positions, bunkers and towers, vehicle fighting positions, and artillery positions. While individual and crew-served weapon fighting positions can be—and often are—constructed entirely without engineer support, the other categories (bunkers and towers, vehicle fighting positions, and artillery positions) usually require engineer support. This chapter provides planning, design, and construction considerations for fighting positions, focusing on those aspects that most commonly require engineer support.

PLANNING AND DESIGNING FIGHTING POSITIONS

4-1. Fighting positions should be selected, designed, and built to support a unit's direct and indirect fires while simultaneously enhancing the protection provided to the individuals or vehicles occupying those positions. When planning and designing fighting positions, several basic design requirements must be considered. These design requirements will help to ensure that the positions are effective. Requirement considerations include weapons employment, cover, simplicity and economy, ingenuity, and progressive development.

WEAPON EMPLOYMENT

4-2. Although it is desirable for a fighting position to provide maximum protection to personnel and equipment, the primary consideration is always given to effective weapons employment. In the offense, fighting positions for weapons systems are often sited where natural or existing positions are available or where terrain will provide the most protection—while maintaining the ability to engage the enemy in a selected EA. Because of the speed typically associated with offensive tasks, these positions are sited where minimal preparation and digging are required. In the defense, when more time may be available, positioning of weapons systems for the most effective employment becomes more critical. The best use of available terrain is always considered, but in the defense, terrain may be modified or changed to provide the most protection while still maximizing the capabilities of the weapons system. It is the responsibility of the unit, not the engineer, to locate the unit's positions where they are most effective.

COVER

4-3. Fighting positions are designed to allow the most effective use of weapons systems, while providing the maximum amount of protection to Soldiers/Marines and their equipment. The primary function of most fighting positions is to defeat the effects of conventional direct and indirect fire. When nuclear and chemical attacks or other threats (to include EHs) are anticipated, the design of the fighting position must consider the potential effect of the enemy weapon or threat and increase the protection level accordingly. Designing and constructing fighting positions will be based on the type of cover that is needed to defeat the particular effects of enemy weapons systems. The following three different types of cover are used to make fighting positions more survivable:

- **Frontal cover**. The primary purpose of frontal cover is to provide protection from direct-fire weapons, but it also provides some protection from the effects of indirect-fire weapons. Use of

effective natural frontal cover such as rocks, thick trees, thick logs, and rubble is preferred because it is more difficult for the enemy to detect. In selecting a construction material, consider its capability to withstand enemy weapons effects, its potential to produce secondary shrapnel, and its ability to improve concealment. If these natural materials are not available or not adequate to provide the desired protection, it then becomes paramount to employ spoil (excavated from the fighting position and compacted) as frontal cover. Frontal cover requires that the fighting positions be built to correct dimensions to allow Soldiers/Marines adequate room to move and fight. It also requires adequate thickness necessary to stop small caliber direct fire and correct height to facilitate proper overhead protection. Constructing cover to protect from large caliber (greater than 12.7 millimeters) direct-fire weapons can be very difficult and resource-intensive. It is usually easier to achieve such protection by placing positions where the enemy cannot effectively engage them, and by concealing them, making pinpointing the exact location difficult.

- **Overhead cover**. The primary purpose of overhead cover is to provide protection from indirect fire and fragmentation, but it also provides some protection from direct fires delivered from a higher position (for example, from a hill) or from enemy aircraft. When possible, overhead cover is always constructed to enhance protection against airburst indirect-fire rounds. Overhead cover dramatically increases survivability and protection for a position. Most individual fighting positions will not be constructed to withstand a contact burst from an indirect-fire weapon.

CAUTION

Improper construction of overhead cover can lead to collapse and result in injury or death to Soldiers/Marines. One common construction error is the lack of support (beams) on which to stabilize the stringers. Another error is improper spacing of stringers. Eighteen inches of overhead cover provided by sandbags can weigh up to 4,000 pounds on a two-person fighting position. It is critical that positions are built according to established guidelines outlined in this ATP, FM 5-34/MCRP 3-17A, and GTA 05-08-001.

- **Flank and rear cover**. The primary purpose of flank and rear cover is to provide protection from the effects of indirect fire to the flanks and rear of the position, and the effects of friendly fire hazards such as the petals from discarding sabot ammunition. Flank and rear cover also provides some protection against direct fire delivered from the flank or rear of the position. In ideal conditions, natural cover and terrain provide this type of cover; however, in urban environments, it is often desirable to take advantage of existing manmade cover. If this is not possible, flank and rear cover are constructed as the situation permits.

SIMPLICITY AND ECONOMY

4-4. Normal characteristics of fighting positions are simplicity and strength, providing the maximum amount of protection possible to the Soldier/Marine and equipment. Providing this protection through the use of readily available materials or existing structures is typically the most desirable as this requires the least amount of engineer equipment to construct the position. Occupying (and modifying, if necessary) existing positions can also save significant time and resources over constructing new positions.

INGENUITY

4-5. The most effective use of available materials and time requires a high degree of imagination. Various materials found on the battlefield, and prefabricated materials from built-up areas and industrial sites, make excellent fighting position components.

PROGRESSIVE DEVELOPMENT

4-6. Fighting positions should be progressively developed as time and situation permit. Hasty fighting positions provide immediate protection for Soldiers/Marines, but to a minimum degree. As time and resources are available, these positions should be improved into deliberate positions as quickly as possible. Given available time, fighting positions may be enhanced by the construction of tunnels and trenches connecting other fighting positions nearby. This provides the flexibility to move from position to position for engagements or resupply while remaining protected. Positions with grenade sumps and drainage increase the level of survivability.

4-7. In cases where design and development of fighting positions can be planned well ahead of their actual emplacement, deliberate positions can be located and bills of material can be identified for their construction. In addition, where advanced planning is possible, more effective and more efficient construction materials can be employed in fighting position construction, such as concrete barriers, soil-filled containers, or other materials. Such materials are especially advantageous for overhead cover. Using these materials can save time in both obtaining protective materials and in constructing fighting positions.

INDIVIDUAL FIGHTING POSITIONS

4-8. Individual fighting positions protect one or more dismounted Soldiers/Marines armed with individual weapons—intended to be operated by an individual rather than by a crew—while supporting their ability to engage the enemy from the position. Such positions typically consist of a hole in the ground, supplemented with frontal, overhead, and flank or rear cover as the time and situation permit. Individual fighting positions are generally constructed in the defense in generally rural areas. Other individual fighting positions may be constructed in urban terrain (see chapter 8) or may be constructed in support of base camps. The positions should be planned and designed so that they are concealed, mutually supporting, and have interlocking fields of fire in all directions. Each weapons system must be assigned a primary sector of fire to support the defensive plan. Alternate positions that overwatch the primary sector should also be selected. Finally, each weapon should be assigned a supplementary position to engage attacks from other directions.

4-9. Design considerations include the mission variables and the following:

- **Availability of materials**. Certain materials such as logs and dressed lumber may be available locally. Other materials (such as U-shaped pickets, sandbags, plywood, and specialized materials) may be acquired through the supply system.
- **Soil**. Soil type is a design consideration when constructing individual fighting positions. Different soils can affect the integrity of the fighting position hole and its ability to remain structurally stable and drain off rainwater. In general, the looser the soil the more standoff from the edge of a fighting position will be required when placing supports for overhead cover.
- **Drainage**. Water can seriously degrade the structural stability of a fighting position and create unhealthy conditions for Soldiers/Marines occupying them. Proper drainage is often difficult to achieve when constructing fighting positions. In areas or seasons where rainfall is expected, drainage or some form of waterproofing should be implemented. The use of sumps, gravel, or wood decking at the bottom of positions will assist in water drainage and help protect Soldiers/Marines from the water. Additionally, waterproofing overhead cover using plastic garbage bags, ponchos, or other suitable material will help prevent water infiltration. Care should also be taken to ensure that the surrounding terrain drains water away from fighting positions.
- **Safety**. Care should be taken not to deviate from designs established in this and other Army and Marine Corps references. The collapse of fighting positions has lead to death and serious injury due to improper construction. See the caution statement, page 4-2.

4-10. Individual fighting positions are categorized in two types: hasty and deliberate. The type of position constructed depends on time, equipment available, and the required level of protection. Characteristics and planning factors for individual fighting positions are found in table 4-1, page 4-4.

4-11. Soldiers/Marines are responsible for constructing their individual fighting positions. They use hand tools and the detailed descriptions and construction procedures found in FM 3-21.8, FM 3-21.75, FM 5-34/MCRP 3-17A, GTA 05-08-001, GTA 07-06-001, and MCWP 3-11.2. See ATTP 3-06.11 for information about individual fighting positions in urban terrain. While engineer support is desirable, supported commanders usually allocate such support to other tasks ahead of supporting the construction of individual fighting positions. When engineer support is available to support individual fighting positions, it should be used to assist with the most time-consuming and labor-intensive tasks—such as digging holes—or tasks requiring special equipment or expertise. Engineers typically use engineer equipment to support the digging effort, but rocky areas may require the use of explosives. Clearing the site of boulders, trees, roots, or other obstructions may require heavy engineer equipment, explosives, chain saws, or other engineer tools and equipment. Care should be taken, however, to minimize disruptions to the site that will make camouflage and concealment more difficult or less effective. Engineers can also assist with clearing selected obstructions from the fields of fire.

Table 4-1. Characteristics of individual fighting positions

Type	***Position***	***Estimated Construction Time[1] (Man-Hours)***	***Protection Provided***				***Remarks***
			Direct Small Caliber Fire	***Indirect-fire Blast and Fragmentation (Near-Miss)[2]***	***Indirect-fire Blast and Fragmentation (Direct Hit)***	***Nuclear Weapons[3]***	
Hasty	Prone position	1.0	7.62 mm	Better than in open–no overhead protection	None	Fair	Provides all-around cover.
Deliberate	One-person position	3.0	12.7 mm	Medium artillery no closer than 30 feet–no overhead protection	None	Fair	—
	One-person position with 1.5 feet overhead cover	8.0	12.7 mm	Medium artillery no closer than 30 feet	None	Good	Additional cover provides protection from direct hit small mortar blast.
	Two-person position	6.0	12.7 mm	Medium artillery no closer than 30 feet–no overhead protection	None	Fair	—
	Two-person position with 1.5 feet overhead cover	11.0	12.7 mm	Medium artillery no closer than 30 feet	None	Good	Additional cover provides protection from direct hit small mortar blast.
	SLM position	3.0	12.7 mm	Medium artillery no closer than 30 feet–no overhead protection	None	Fair	—

Table 4-1. Characteristics of individual fighting positions (continued)

Note.
Chemical protection is assumed because of individual protective masks and clothing.
A dash indicates no data.
[1] Estimated construction time assumes use of hand tools to prepare the position.
[2] Shell sizes are—

	Light	Medium
Mortar	82 mm	120 mm
Artillery	105 mm	152 mm

[3] Nuclear protection ratings are rated poor, fair, good, very good, and excellent.

Legend:
mm – millimeter
SLM – shoulder-launched munition
x – times

HASTY POSITIONS

4-12. When time and materials are limited, troops in contact with the enemy use a hasty fighting position located behind whatever cover is available, maximizing the advantages provided by the existing terrain and natural or manmade cover. Hasty positions may only provide limited protection; however, positions should be selected to provide, as a minimum, frontal protection from direct fire while allowing Soldiers/Marines to fire to the front and oblique. Because of the situation and limited time typically associated with selecting a hasty position, extreme care must be taken to select a position that will reduce the risk of fratricide. For protection from indirect fire, a hasty fighting position can be located in a depression or hole that is at least l ½ feet deep. While there may be little or no natural cover, these positions can provide limited protection from fragmentation. If the unit remains in the area and/or as the situation permits, hasty positions should be continually improved to provide as much protection as possible. See FM 3-21.75 and MCWP 3-11.2 for additional information on hasty individual fighting positions.

DELIBERATE POSITIONS

4-13. Deliberate fighting positions are often modified hasty positions prepared as the situation and time permit. The unit leader should verify the sectors of observation/fire, interlocking fields of fire, adequate size for occupants, and safe backblast areas before improving each position. Continued improvements are made to strengthen the position during the period of occupation. In some cases, particularly in urban environments, it may be necessary to 'build up' or construct a position within an existing structure. Improvements include adding overhead cover, digging trenches or opening routes to adjacent positions, and maintaining camouflage. Chapter 6 provides information about camouflage and concealment of fighting positions. FM 3-21.75 provides detailed information about deliberate individual fighting positions and additional information can be found in FM 3-21.8, FM 5-34/MCRP 3-17A, GTA 05-08-001, GTA 07-06-001, and MCWP 3-11.2. For material thicknesses for different types of material against specific threats, see tables 3-1 through 3-5 on pages 3-7 through 3-11.

CREW-SERVED WEAPONS FIGHTING POSITIONS

4-14. Like individual positions, crew-served weapons positions are also classified as hasty and deliberate. The same principles apply to the crew-served weapon, although minor changes include dimensions of the position and characteristics to facilitate effective use of the weapon system. Frontal, overhead, flank, and rear protection provide increased survivability and protection as well. For crew-served weapons that create a backblast, overhead and rear protection must be considered for effective employment of the weapon while minimizing the risk of injury to the operator.

4-15. As with individual fighting positions, Soldiers/Marines are responsible for constructing their crew-served weapon fighting positions. These positions must be tailored to the operating characteristics and requirements of the weapon that will occupy the position. Weapon crews—and their leaders—must thoroughly understand and apply the descriptions and procedures for constructing fighting positions (found in the manuals listed in table 4-2, page 4-6) and camouflage and concealment of fighting positions (found in chapter 6). In addition, see ATTP 3-06.11 for information about crew-served weapon positions in urban terrain.

Table 4-2. References for crew-served weapon fighting positions

Weapon	Reference
Javelin	FM 3-22.37
Tube-launched, optically-tracked, wire-guided missile	FM 3-21.91 and FM 3-22.34/MCWP 3-15.4
Machine gun	FM 3-21.8, FM 3-21.75, FM 3-22.27, FM 3-22.65, FM 3-22.68, and MCWP 3-15.1
Mortar	ATTP 3-21.90/MCWP 3-15.2
Legend: ATTP – Army tactics, techniques, and procedures FM – field manual MCWP – Marine Corps warfighting publication	

4-16. When engineer support for fighting positions is available, supported commanders often give higher priority to supporting construction of fighting positions for crew-served weapons than to individual fighting positions. As with individual fighting positions, available engineer support should be used to assist with the most time-consuming and labor-intensive tasks, or those requiring special equipment or expertise. Engineer support to crew-served weapon fighting positions typically involves the same types of tasks used to support individual fighting positions—digging, cutting, and clearing. Characteristics and planning factors for crew-served fighting positions are found in table 4-3.

Table 4-3. Characteristics of crew-served weapons fighting positions

Type of Position	Estimated Construction Time[1] (Man-Hours)	Protection Provided			
		Direct Small Caliber Fire	Indirect-fire Blast and Fragmentation (Near-Miss)[2]	Indirect-fire Blast and Fragmentation (Direct Hit)	Nuclear Weapons[3]
Javelin position	4.0	12.7 mm	Medium artillery no closer than 30 feet–no overhead protection	None	Fair
Dismounted TOW missile position	11.0	12.7 mm	Medium artillery no closer than 30 feet–no overhead protection	None	Fair
Machine gun position	7.0	12.7 mm	Medium artillery no closer than 30 feet–no overhead protection	None	Fair
Machine gun position with 1 ½ feet overhead cover	12.0	12.7 mm	Medium artillery no closer than 30 feet	None	Good
Mortar position	14.0	12.7 mm	Medium artillery no closer than 30 feet–no overhead protection	None	Fair

Note.
Chemical protection is assumed because of individual protective masks and clothing.
A dash indicates no data.
[1] Estimated construction time assumes use of hand tools to prepare the position.
[2] Shell sizes are—

	Light	Medium
Mortar	82 mm	120 mm
Artillery	105 mm	152 mm

[3] Nuclear protection ratings are rated poor, fair, good, very good, and excellent.
Legend:
mm – millimeter   TOW – tube-launched optically-tracked wire-guided   x – times

BUNKERS AND TOWERS

4-17. Base camps will generally require fighting positions in the form of bunkers and towers. These are generally constructed above ground using timber, sandbags, soil-filled containers, prefabricated concrete, or other specific items that are available through the supply system. These positions are employed to support perimeter security, security of key sites such as enemy prisoner of war compounds, and ECPs. A deliberate defense may also involve the construction of more elaborate bunkers that may hold up to a squad of Soldiers/Marines.

4-18. Bunkers are larger fighting positions constructed for squad-size (or potentially larger) units that are required to remain in defensive positions for a longer period of time. They are built either above- or belowground and are usually made of reinforced concrete, but can be designed and constructed with a variety of materials. Because of the extensive engineer effort required to build bunkers, they are usually constructed when preparing strong points or protecting vital facilities such as base camps. If time permits, bunkers are connected to other fighting or supply positions by tunnels. Prefabrication of bunker assemblies affords rapid construction and placement flexibility. Bunkers offer excellent protection against direct fire and indirect-fire effects and, if properly constructed with appropriate collective protection equipment, can provide protection against chemical and biological agents.

4-19. The positions described below (in paragraphs 4-20 through 4-23) are designed for use by two or more individuals armed with rifles or machine guns. Although these are beyond the construction capabilities of nonengineer troops, certain construction phases can be accomplished with little or no engineer assistance. For example, while engineer assistance may be necessary to build steel frames and cut timbers for the roof of a structure; the excavation, assembly, and installation are all within the capabilities of most units. Adequate support for overhead cover is extremely important. The support system should be strong enough to safely support the roof and soil material and survive the effects of weapon detonations. FM 5-34/MCRP 3-17A, GTA 90-01-011, and the Theater Construction Management System (TCMS) provide additional designs, information, construction techniques, and bills of material.

SOIL-FILLED CONTAINER FIGHTING POSITIONS

4-20. Soil-filled container positions can be quickly constructed and provide a high degree of survivability. They are most commonly used above ground, but the soil-filled container will provide increased ability when partially buried. Soil-filled containers are available through normal supply channels and, when employed correctly, provide a high degree of protection against blast and fragmentation. When using soil-filled containers, Soldiers/Marines must ensure that proper overhead cover frames are used in the construction to prevent cave-ins from occurring. Some preparation may be required for the base of the position if the foundation soil is unsuitable or if longer term emplacement is anticipated. GTA 90-01-011 shows several designs (including bills of materials; estimates of equipment, personnel, and time requirements; and construction steps) using soil-filled containers for construction of fighting positions, observation posts, and bunkers.

WOOD OR STEEL-FRAME FIGHTING POSITION

4-21. The wood-frame or steel-frame fighting position consists of prefabricated timber or steel-frame support elements that support a timber or concrete roof. The position is useful as a two-person fighting or observation position in areas where it can be dug into the ground. (See appendix D for information on roof design.)

CORRUGATED METAL WALL BUNKERS

4-22. A bunker made from corrugated metal walls is very useful in areas where digging is not possible or practical. With 4-foot, earth-filled walls and 2-foot overhead cover, this position defeats direct fire and blasts or fragments from near miss mortar and artillery ammunition. The upper portion of the bunker is left open for maximum visibility in all directions.

PLYWOOD PERIMETER BUNKER

4-23. A plywood perimeter bunker is used as an aboveground protected observation post. The bunker has a post foundation or can be constructed on the ground. Another option is to build the wood bunker on top of one or two stacked CONEX boxes. Walls of this bunker will need to be earth filled or otherwise hardened to resist the applicable threat.

VEHICLE FIGHTING POSITIONS

4-24. Vehicle fighting positions include fighting and protective positions for major weapons systems vehicles and their support equipment. Initially, vehicles use the natural cover and concealment in hide positions to increase survivability. As time, assets, and situation permit, positions are prepared using engineer support. Priority is given to those vehicles containing essential critical equipment or supplies. Drivers and crews should also use these fighting positions for individual protection.

4-25. Berms and revetments positioned at the front of or around major weapons systems will provide improved protection from direct fire and from blast and fragments of indirect-fire artillery, mortar, and rocket shells. At its base, a berm has a thickness of at least 8 feet. Further, the berm or revetment functions as a standoff barrier for impact-detonating, direct-fire HEAT and antitank guided missile (ATGM) projectiles. It should cause the fuzes to activate, thereby increasing survivability for the protected vehicles. If the expected enemy uses kinetic energy direct-fire armor piercing or hypervelocity projectiles, it is impossible to construct berms thick enough for protection. To protect against these projectiles, prepare deep-cut, hull defilade, or turret defilade positions. Construct fighting and protective positions that are no larger than operationally necessary.

4-26. Success on the battlefield requires maneuver between hide and fighting positions between main gun firings. Maximum use of wadis or draws, reversed slope hills, and natural concealment is required to conceal fighting vehicles maneuvering among fighting positions. When a major weapon system fires its main gun, the vehicle and gun may make a concealed maneuver to another position before firing again. If the major weapon system immediately reappears in the old position, the enemy will know where to fire the next round. Table 4-4 provides a summary of the dimensions of the hasty and deliberate vehicle positions discussed above. (See the vehicles' respective operator's manuals for more detailed vehicle dimensions.) Construction planning factors for vehicle fighting positions are shown there as well. Chapter 6 provides information about camouflage and concealment of fighting positions.

Table 4-4. Dimensions of vehicle positions

Vehicle Types		Position Dimension (feet)[2]			Equipment Hours[4]	Minimum Berm Thickness at Base (feet)[5]
		Length	Width	Depth[3]	D7 Dozer/M9 ACE/MCT	
Hasty[1]	Stryker vehicle (all variants) with slat armor	32	19	9	1.6	8
	M113 series carrier	22	14	6	0.6	8
	M577 command post vehicle	22	14	9	0.8	8
	M106 and M125 mortar carrier	22	16	7	0.7	8
	AAV with armor kit	33	19	11	2.0	8
	LAV with armor kit	27	25	9	1.7	8
Deliberate	Hull Defilade					
	M113 series carrier	22	14	6	0.6	NA
	M577 command post vehicle	22	14	9	0.8	NA
	M106 and M125 mortar carrier	22	16	7	0.7	NA
	M2 and M3 fighting vehicle	26	16	7	0.8	NA
	M1 main battle tank	32	18	5.5	0.9	NA
	AAV with armor kit	33	19	11	2.0	NA
	LAV with armor kit	27	25	9	1.7	NA

Table 4-4. Dimensions of vehicle positions (continued)

	Vehicle Types	Position Dimension (feet)[2]			Equipment Hours[4]	Minimum Berm Thickness at Base (feet)[5]
		Length	Width	Depth[3]	D7 Dozer/M9 ACE/MCT	
Deliberate	Access Route	Each access route between positions or hide locations must have the same width as the hull defilade. Clearing times are planned using FM 5-34/MCRP 3-17A. Production time is determined by calculating the volume of soil needed to be moved (in cubic yards) and dividing by 100 bank cubic yards per 0.75 hour.				
	Hide Location	Hide locations are made using natural terrain and concealment. Ground clearing times are planned with the use of FM 5-34/MCRP 3-17A. The minimum width of the hide location is the same as the deliberate hull defilade. The hide position depth requirement is calculated by increasing the depth given in the deliberate turret defilade position by 15 percent.				
	Turret Defilade					
	Stryker vehicle (all variants) with slat armor	32	19	9	1.6	NA
	M113 series carrier	22	14	7.5	0.7	NA
	M2 and M3 fighting vehicle	26	16	10	1.2	NA
	M1 main battle tank	32	18	9	1.5	NA
	AAV with armor kit	33	19	13	2.3	NA
	LAV with armor kit	27	25	12	2.3	NA

[1] Hasty positions for tanks and infantry fighting vehicles not recommended.
[2] Position dimensions provide an approximate 3-foot clearance around vehicle for movement and maintenance and do not include access ramp(s).
[3] Total depth includes any berm height. All depths are approximate and will need adjustment for surrounding terrain and fields of fire.
[4] This column provides rules of thumb which are useful (in the absence of actual production rate data) as a starting point to estimate time required to prepare fighting positions. These equipment hours are based on a production rate of 100 bank cubic yards per 0.75 hour. Divide construction time by 0.85 for rocky or hard soil, night conditions, or closed hatch operations (M9). Use of natural terrain features will reduce construction time. See TM 3-34.62 for more information about estimating production rates.
[5] Berms are not recommended for hull and turret defilade positions.

Legend:
AAV – assault amphibious vehicle
ACE – armored combat earthmover
FM – field manual
LAV – light armored vehicle
MCRP – Marine Corps reference publication
MCT – medium crawler tractor
NA – not applicable

HASTY POSITIONS

4-27. Hasty fighting positions for combat vehicles take advantage of natural terrain features or are prepared with a minimum of construction effort. A frontal berm, as high as practical without interfering with the vehicle’s weapon systems, shields from frontal attack and provides limited concealment if properly camouflaged. Protection is improved if the position is made deeper and the berm extended around the vehicle's sides. Because of the false sense of security provided by berms against kinetic energy and hypervelocity projectiles, hasty vehicle fighting positions with berms are not recommended for tanks, infantry fighting vehicles, or Stryker mobile gun systems. Hasty fighting positions do offer protection from HEAT projectiles and provide limited concealment if properly camouflaged. As the tactical situation permits, hasty positions for combat vehicles are improved to deliberate positions.

DELIBERATE POSITIONS

4-28. Deliberate fighting positions are required to protect a vehicle from kinetic energy and hypervelocity projectiles. Deliberate vehicle fighting positions are holes in the ground which provide cover and concealment, reducing the target signature. The position is constructed in four parts: hull defilade, turret defilade, concealed access ramp or route, and hide location. Positions formed by natural terrain are best because of easy modification; however, if preparation is necessary, extensive engineer support is required. Each position is camouflaged with either natural vegetation or a camouflage net, and the spoil is flattened out or hauled away. All fighting positions for fighting vehicles (tanks, infantry fighting vehicles, and Stryker mobile gun systems) are planned as deliberate positions. Since lack of time usually limits the full construction of a deliberate position, only some parts of the position's construction are prepared. For example, the complete fighting position for a tank requires the construction of a hull defilade, a turret defilade, a concealed access ramp or route, and a hide location–all within the same fighting position. The

maneuver team commander uses engineer earthmoving assets and usually constructs fighting position parts in the following order:

- **Hull defilade**. This position leaves the vehicle's turret above ground, allowing it to observe and engage targets.
- **Turret defilade**. The entire vehicle is belowground level. A hull defilade position is required in front of the vehicle to allow it to move up to engage targets.
- **Hide location**. The hide location allows the vehicle to be concealed away from the fighting position, and includes overhead concealment when possible.
- **Concealed access ramp or route**. A concealed route, either natural or constructed, allows the vehicle to move from its hide position to its fighting positions.

4-29. When developing deliberate positions, construction of hide locations and a concealed route between positions is only done when time and engineer assets are available. When limited time is available, engineer assets should be prioritized to concentrate on hull and turret defilade positions. Once the commander's priorities are complete, hide positions and concealed routes can begin. The ramps and concealed routes should require only partial clearing and leveling with engineer equipment because natural concealed routes and hide positions are used. In terrain where natural concealed routes and hide positions are not available, commanders must consider employing organic obscuration equipment when vehicles are occupying primary fighting positions or repositioning. Artillery or mortar-delivered smoke and smoke generators may provide this obscuration. The use of smoke may be a two-edged sword since it alerts the enemy to activity that may be occurring. Figures 4-1 and 4-2 depict what a fully developed deliberate vehicle fighting position may look like.

4-30. The terrain, the type of soil, and the water table will all influence the construction of vehicle fighting positions. In many cases, the depth of soil to bedrock or to the water table will prevent or hinder the construction of positions. This concern may impact a specific vehicle position or an entire unit BP. Commanders must sometimes consider the competing requirements of vehicle positions against the ability to excavate the desired fighting positions. For units remaining in place for extended periods of time, measures must be taken to prevent or mitigate erosion and drainage problems.

Figure 4-1. M1 tank (hull defilade)

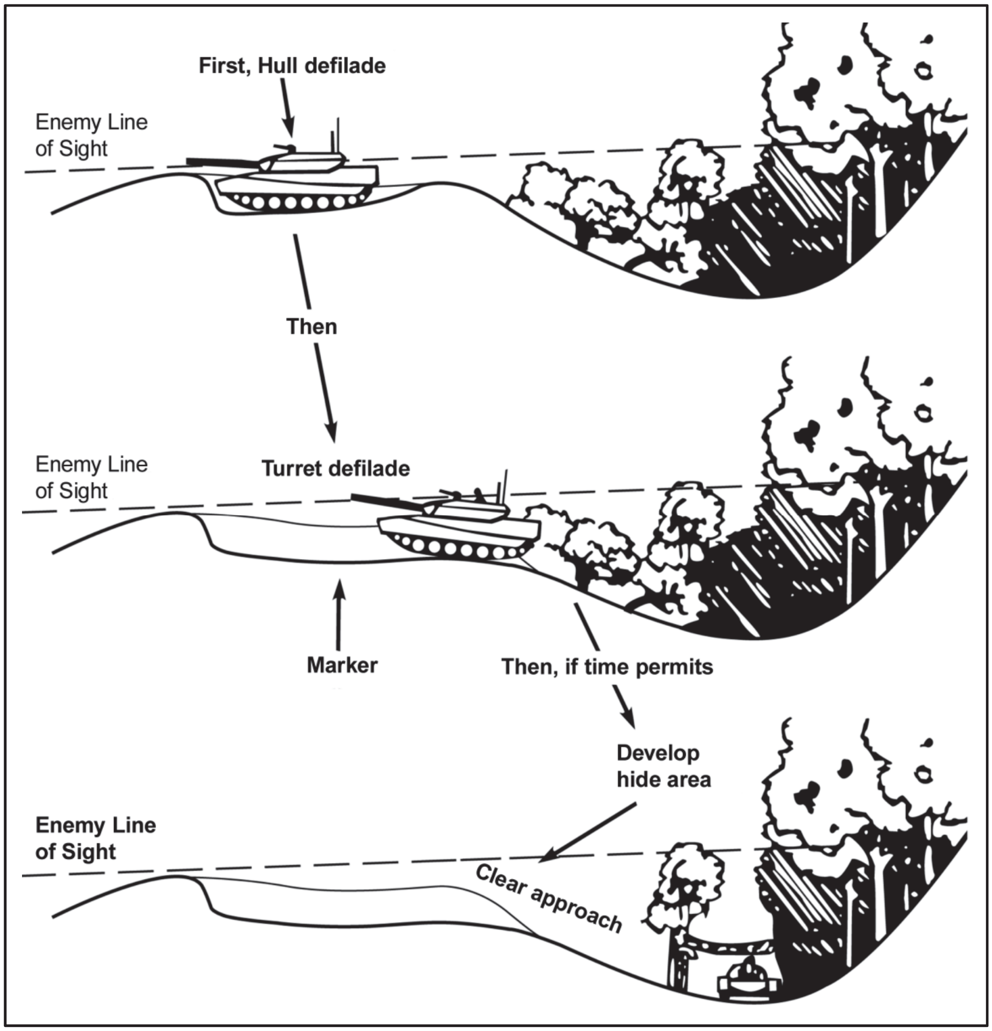

Figure 4-2. Fully developed deliberate fighting position

MARKING

4-31. When fighting positions are planned, it is extremely important to mark the positions (for recognition during day and night) and understand when and how the positions will be occupied. This maximizes the time available for construction and ensures that the fighting positions meet the intent of the maneuver commander. Maneuver commanders and vehicle commanders will mark the position and then be available when engineer assets begin digging. It is the vehicle commander's responsibility to check the position for proper depth and line of sight (LOS) before releasing engineer assets to move to the next position. The vehicle commander or his representative must remain present during the construction of the fighting position. Once the leader is satisfied that the position meets standards and can properly engage his sector, the engineer assets will be released for their next prioritized mission. It is the maneuver unit commander's responsibility to ensure that fighting positions are correctly sited, and it is the engineer commander's responsibility to enforce construction standards.

COMPANY AND BATTALION BATTLE POSITIONS

4-32. The creation of company- and battalion-sized BPs involves the construction of numerous fighting and protective positions to meet the commander's intent for those particular sites. That intent will be linked to the defensive plan (see FM 90-7). Although engineers are responsible for prioritizing the engineer effort

within the commander's guidance and constructing fighting positions to standard, the maneuver unit is responsible for siting each position and developing the BP. The maneuver unit should designate a representative (typically the unit's senior NCO (Army)/senior staff NCO (Marine Corps) or executive officer) as the on-site point of contact to guide the execution of the required engineer support. There are five kinds of BPs: primary, alternate, supplementary, subsequent, and strong point. All BPs require survivability and countermobility support, but the creation of a strong point requires significant time, resources, and engineer effort to create. See FM 3-90-1 for more information.

EXCAVATION CAPABILITY PLANNING FACTORS

4-33. The basic excavation capabilities of the most likely survivability equipment supporting a BCT/RCT are shown in table 4-5. These planning factors may be further influenced by the condition of the soil, terrain, weather and weather-related effects; maintenance of the vehicles; personnel availability; and other potential significant influences on their performance.

4-34. These capability estimates can be used to estimate the time required to excavate for various fighting and protective positions, in the event that other tables do not include the information necessary for a specific vehicle or situation. In that event, it is necessary to estimate the size of the position required, the amount of material to be moved, and the type of equipment used. FM 5-412/MCRP 3-17.7F provides additional information on estimated earthwork. TM 3-34.62 (which provides estimated production rates, characteristics, operation techniques, and soil considerations for earthmoving equipment) should be used as a guide to selecting the most economical and effective equipment based on the situation.

Table 4-5. Excavation capabilities of selected survivability equipment

	Excavator Capability (cubic yards per hour)	
Equipment	***Banked Material***	***Loose Material***
Armored combat earthmover, M9	163	204
Scoop loader	125	156
Tractor, full tracked, D3	50	60
Tractor, full tracked, D5 (Army)/ MC1150 (Marine Corps)	150	170
Tractor, full tracked, D7 (Army)/ Medium crawler tractor (Marine Corps)	165	211
Tractor, rubber-tired, articulated-steering, multipurpose (TRAM), 624K	125	156
Deployable universal combat earthmover	160	170
High mobility engineer excavator	66	66
Backhoe loader	66	66
Small emplacement excavator	30	40
Utility tractor	30	40
Note. Rates are based on work performed in clayey sand soil with an operator efficiency of 0.83, a 50-minute work hour, and excavated soil being spread or dumped in the immediate vicinity of the excavation site.		

ARTILLERY POSITIONS

4-35. The same principles that apply to hasty individual and crew-served weapons positions also apply to artillery positions when time, materials, and engineer equipment are limited. As time, materials, and engineer equipment permit, artillery positions are improved with firing platforms and berm or revetment positions.

Artillery Firing Platform

4-36. Artillery firing platforms for towed or self-propelled artillery weapons are necessary on soft ground to preclude weapon relaying after each round is fired. The pad distributes the loads over a larger area with no significant settlement and is flexible, level, and strong enough to withstand the turning and movement of self-propelled weapons. The pad allows firing in all directions. Trail logs are anchored outside the pad for towed weapons. For self-propelled weapons, the recoil spades are set in compacted solid material or in a layer of crushed rock around the pad. These positions provide limited protection with the use of a berm or revetment.

Berm or Revetment Positions

4-37. A berm or revetment position for field artillery provides improved protection from near-miss, indirect-fire weapons effects and small caliber direct fire. The berm is constructed with material removed from the excavation and is built low enough to allow direct howitzer fire. It is usually necessary to stabilize the berm to prevent deterioration caused by muzzle blast. The position is camouflaged with natural vegetation or camouflage netting. Table 4-6 gives dimensions of positions for field artillery vehicles. Shelter construction is necessary to provide adequate protection for the firing crew, fire direction center, and CP. Separate shelters are necessary to contain an artillery section's basic load of projectiles, fuzes, and propelling charges. If time allows, firing positions, CPs, and fire direction centers are connected by trenches. See chapter 6 for information about camouflage and concealment of survivability positions.

Table 4-6. Dimensions of field artillery vehicle positions

	Dimension (feet)[1]			*Other Information*		
Vehicle Type	***Length***	***Dimension Width***	***Depth/ Berm Height***[2,4]	***Equipment Hours***[3] ***(D7 Dozer/ M9 ACE/ MCT)***	***Minimum Berm Thickness at Base (feet)***	***Remarks***
105-mm towed howitzer (M102)	21 feet 10-1/2 inches (6.7 meters)	6 feet 4 inches (1.9 meters)	24 inches (0.61 meters)/ 18 inches (0.46 meters)	1 hour	8	–
105-mm towed howitzer (M119A2)	Folded position:16 feet (4.87 meters) With tube in firing position: 20 feet 9 inches (6.32 meters) With tube locked in tube clamp: 20 feet 2 inches (6.15 meters)	5 feet 10 inches (1.78 meters)	24 inches (0.61 meters)/ 18 inches (0.46 meters)	1 hour	8	–
155-mm towed howitzer (M198)	Firing position (without spades): 36 feet 2 inches (11.02 meters) Stowed position: 24 feet 5 inches (7.44 meters) Towed position: 40 feet 6 inches (12.34 meters) Tread (center-to-center): 7 feet 9 inches (2.36 meters)	Towed position: 9 feet 2 inches (2.79 meters)	–	1.5 hours	8	–
155-mm towed howitzer (M777)	33 feet 6 inches (10.21 meters)	12 feet 3 inches (3.72 meters)	–	–	8	–

Table 4-6. Dimensions of field artillery vehicle positions (continued)

	Dimension (feet)[1]			Other Information		
Vehicle Type	**Length**	**Dimension Width**	**Depth/ Berm Height[2,4]**	**Equip-ment Hours[3] (D7 Dozer/ M9 ACE/ MCT)**	**Minimum Berm Thickness at Base (feet)**	**Remarks**
155-mm howitzer self-propelled (M109A6)	Overall length (with baskets to rear): 423 inches (10.7 meters) Overall length (with baskets forward): 392 inches (9.9 meters)	Overall width (with baskets forward): 154 inches (3.9 meters) Overall width (with baskets to rear): 128 inches (3.3 meters)	–	–	–	–

Note.
A dash indicates no data.
[1] Position dimensions provide an approximate 3-foot clearance around vehicle for movement and maintenance and do not include ramp(s).
[2] Total depth includes any berm height.
[3] Production rate of 100 bank cubic yards per 0.75 hour. Divide construction time by 0.85 for rocky or hard soil, night conditions, or closed hatch operations (M9). Use of natural terrain features will reduce construction time.
[4] All depths are approximate and will need adjustment for surrounding terrain and fields of fire.

Legend:
ACE – armored combat earthmover
MCT – medium crawler tractor
mm – millimeter

4-38. Emplacements for towed artillery systems are routinely constructed to increase the weapons systems survivability. These weapons systems are not as mobile as self-propelled systems and require increased survivability measures. Emplacements for towed systems must provide maximum flexibility in the delivery of fire and protect the weapon and crew against the effects of enemy fire. Those positions designed to allow the towed systems to be used in a defensive direct-fire role will have adjusted berm heights that allow firing at 0 mils elevation.

4-39. Trail logs may be necessary to overcome the weapons recoil, while still providing the ability to traverse the artillery piece. Trail logs are commonly constructed in a complete circle to allow the howitzer to pivot 360 degrees. In semipermanent installations, wooden decking may be placed on the floor of the emplacement to assist in drainage and when traversing the howitzer. Protective positions with overhead cover are provided for the personnel ready position and ammunition shelters. (See figure 4-3 and figure 4-4, page 4-16.)

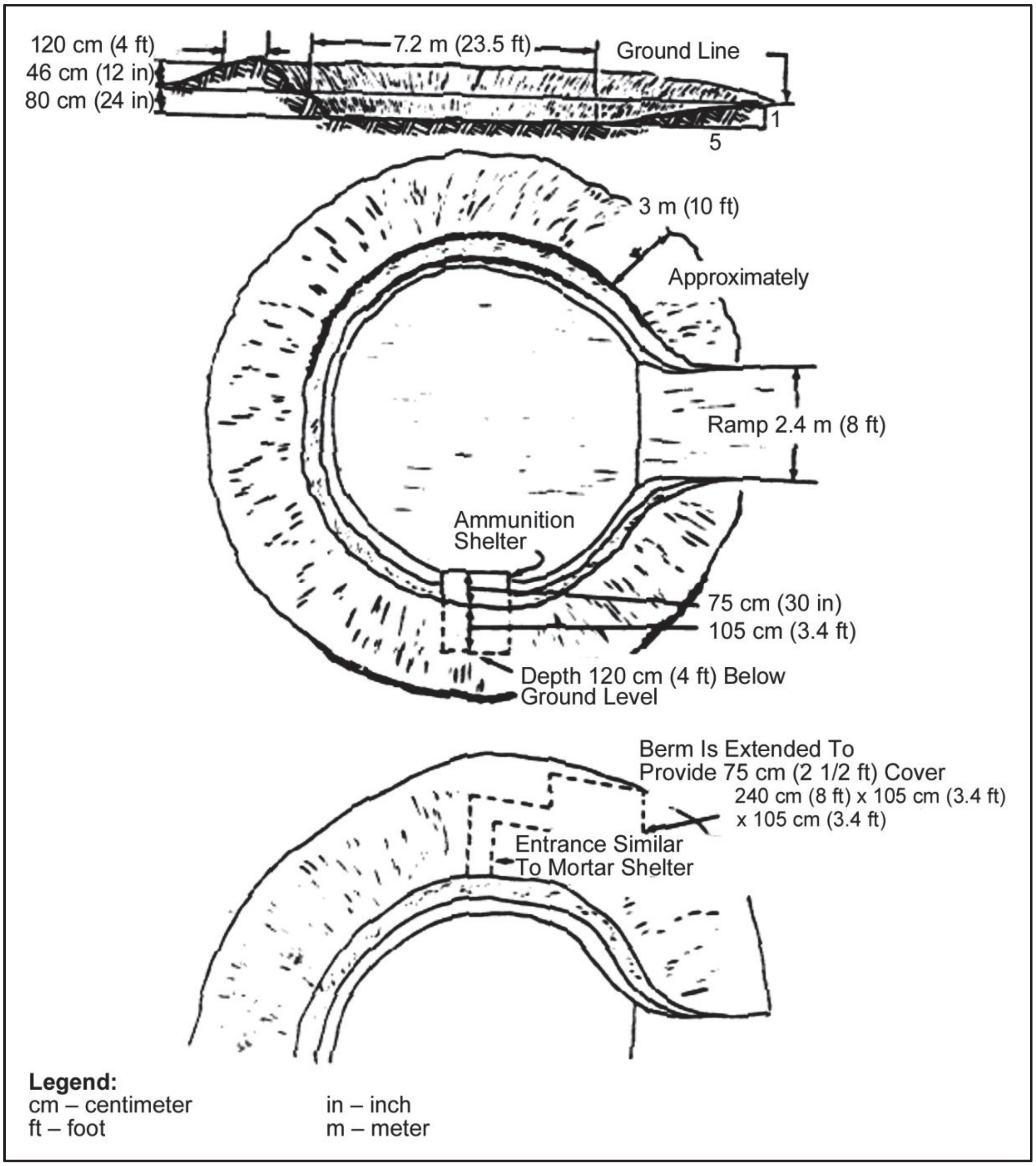

Figure 4-3. Towed howitzer emplacement (105-millimeter and 155-millimeter howitzer) layout

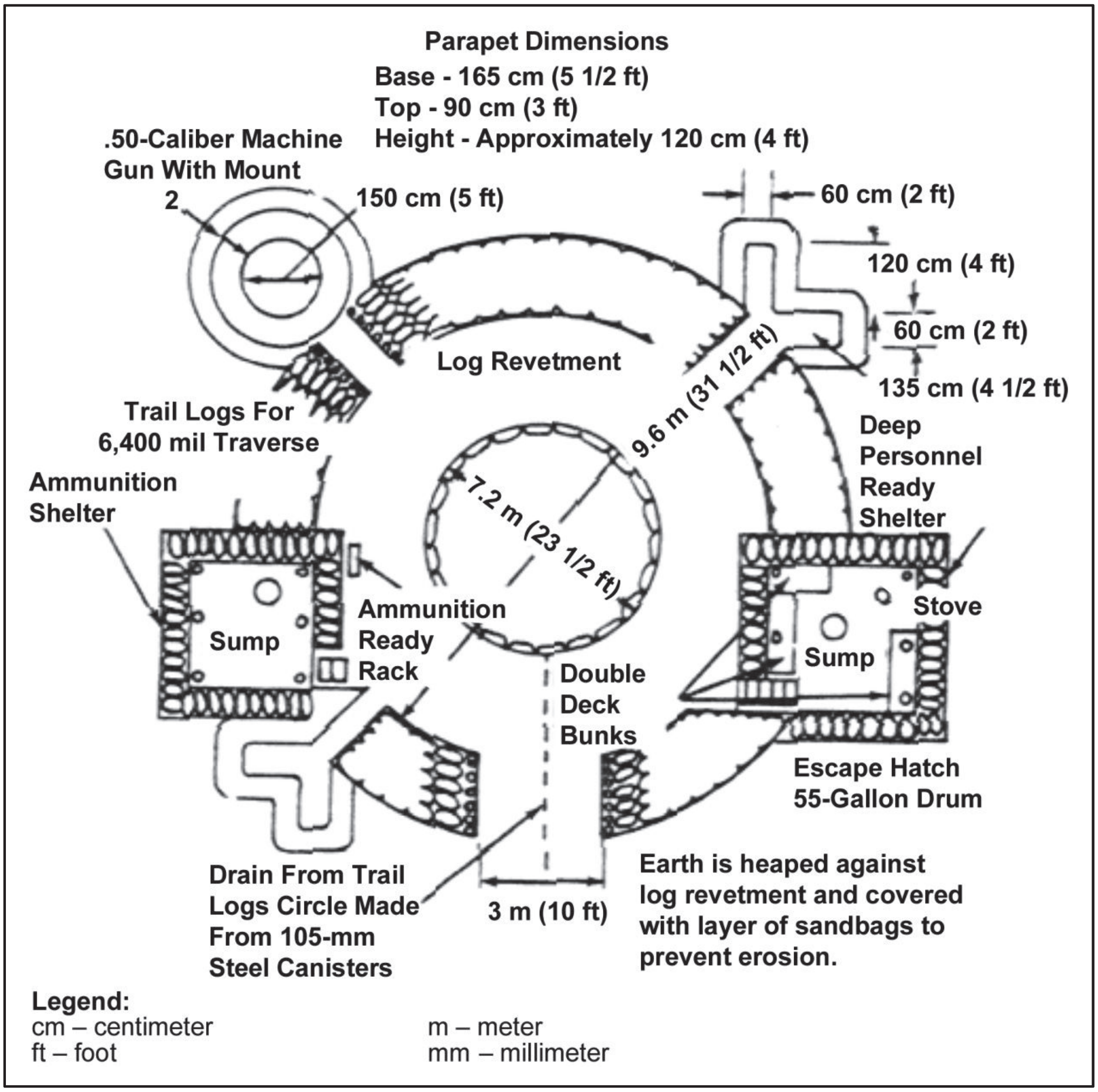

Figure 4-4. Towed howitzer emplacement (105-millimeter and 155-millimeter howitzer) completed emplacement

4-40. Modern self-propelled howitzers are designed to shoot during short halts. The ability to shoot and then reposition quickly provides increased survivability for the weapons systems. Self-propelled howitzers may be positioned on base camps to provide fire support to the local commander's AO. Figure 4-5 portrays a protected firing emplacement for self-propelled howitzers used in this role.

4-41. When positions for self-propelled artillery systems are prepared, a sloped ramp is built to facilitate the vehicles' entry into and exit from the emplacement. Although the hull of the howitzer is protected, leaders must ensure that berms and revetments are not constructed to a height which prohibits the howitzer from depressing to the minimum elevation. This would prevent the weapons system from being used in the direct-fire role. Barrel stops may be used, if necessary, to prevent fire into adjacent units. In temperate or tropical environments, provisions must be made for drainage inside the emplacement.

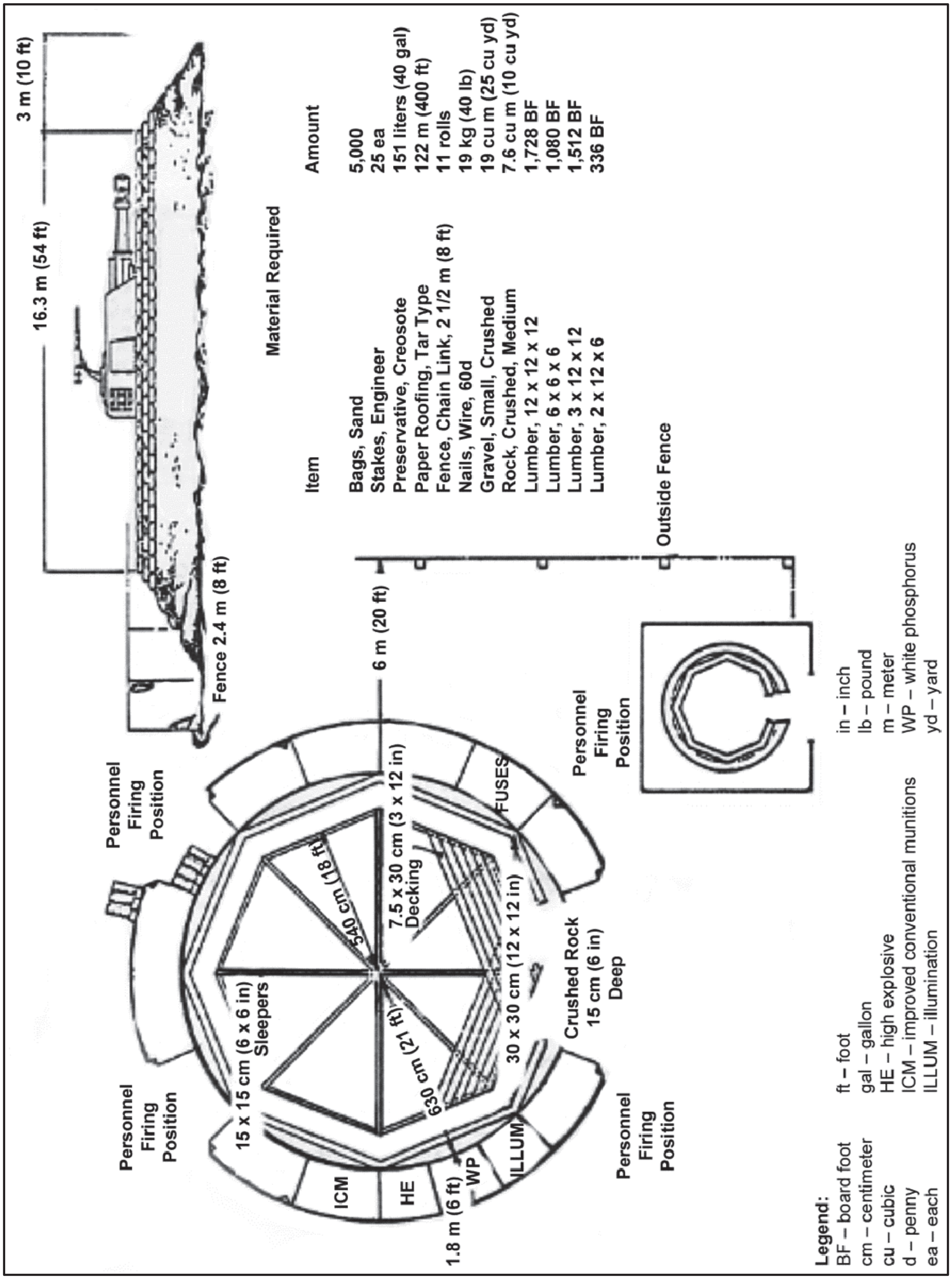

Figure 4-5. Emplacement for 155-millimeter howitzer, self-propelled (M109 series) (semipermanent installation)

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Chapter 5

Protective Positions

This chapter describes some general protection considerations for various sites and the associated protective positions that may be located within an AO. A protective position is one that has been specifically modified and enhanced to repel or minimize enemy weapons effects against personnel, equipment, and facilities. Engineer planners will coordinate with the commander and other staff elements to develop the mission's specific protection criteria during the orders planning sequence and by maintaining the engineer's running estimate. See GTA 90-01-011 for supporting information. This chapter focuses on protective positions for vehicles, equipment, and personnel. Chapter 7 provides additional considerations for other critical assets. (For information on camouflage and concealment of protective positions, see paragraph 6-127.)

VEHICLE AND EQUIPMENT PROTECTIVE POSITIONS

5-1. Vehicle protective positions are constructed for vehicles and weapons systems that are not directly engaged in providing fires against the enemy. These positions generally require extensive engineer assets and construction materials to build. Unless separate overhead cover is constructed, these positions do not provide blast protection from indirect-fire superquick, contact, or delay-fuze shells. These positions, however, provide medium artillery shell fragmentation protection from near-miss bursts greater than five feet from the position and from direct-fire HEAT projectiles 120 millimeters or less.

5-2. A certain degree of protection can be obtained by using the terrain, such as draws, reverse slopes, and urban terrain. These may provide protection by both enhancing camouflage and concealment and by providing protection against blast and fragmentation. Constructed vehicle protective positions include berms, revetments, and deep cut positions. These positions should be high enough to achieve the desired level of protection, large enough to accommodate the vehicle with work space around it, allow easy access, and account for drainage. Deep cut positions may include cuts in hillsides or excavations that allow the vehicle to be positioned belowground level.

5-3. Table 5-1, page 5-2, provides dimensions for protective positions for AN/TPQ-36 and AN/TPQ-37 radar systems. GTA 90-01-011 provides design information for protective positions with overhead cover for heavy expanded mobility tactical trucks and palletized load systems. The design uses soil-filled containers and may be adapted for other vehicles.

Table 5-1. Dimensions of protective positions for AN/TPQ-36 and AN/TPQ-37 radar systems

Dimension Feet					*Other info*	
Vehicle Type	***Length***	***Dimension Width***	***Depth (feet)***	***Berm Height (feet)***	***Platform, Ramp Height/Width/ Entrance, Exit Slope***	***Minimum Berm Thickness at Base (feet)***
AN/TPQ-36 Firefinder Radar						
Shelter/ HMMWV	17 ft, 6 in	15 ft, 4 in	14	8	NA	3
Generator	22 ft	15 ft, 4 in	14	8	NA	3
Antenna Array	15 ft, 4 in	15 ft, 4 in	4	4	8 to 10 ft/15 ft, 4 in/ 30 to 35 degrees	3
AN/TPQ-37 Firefinder Radar						
Shelter/ HMMWV	17 ft, 6 in	15 ft, 4 in	14	8	NA	3
Prime Mover and Reconnaissance Vehicle	22 ft	20 ft	14	8	NA	3
Generator	17 ft, 6 in	16 ft	14	8	NA	3
Antenna Array	16 ft	16 ft	0	6	NA	3
Legend: ft – foot HMMWV – high mobility multipurpose wheeled vehicle in – inch NA – not applicable						

OBSERVATION POSTS AND PROTECTIVE SHELTERS

5-4. Shelters are primarily constructed to protect Soldiers/Marines, equipment, and supplies from enemy action and the weather. Shelters differ from fighting positions because there are usually no provisions for firing weapons from them. However, they are often constructed to supplement fighting positions. Observation posts must also allow Soldiers/Marines to have clear observation of their assigned sector. As a result, the techniques employed for fighting positions, bunkers, and towers (which are discussed in chapter 4), and for protective shelters (discussed below) can all be used to create effective observation posts, but may require modification to adapt to the requirement for observation.

5-5. When available, natural shelters such as caves, mines, or tunnels are used instead of constructing shelters. Caves, mines, tunnels, or storage bunkers used for extended periods should be checked for environmental health hazards that may impact Soldier/Marine health, to include ammunition residue, hazardous materials, and potential disease-spreading vectors. Engineers are consulted to determine the suitability of caves and tunnels. The best shelter is usually one that provides the most protection but requires the least amount of effort to construct. Shelters are frequently prepared by support troops, troops making a temporary halt due to inclement weather, and units in bivouacs, AAs, and rest areas. Shelters are constructed with as much overhead cover as possible. They are dispersed and limited to a maximum capacity of about 25 Soldiers/Marines. Supply shelters are of any size, depending on location, time, and materials available. Large shelters require additional camouflaged entrances and exits.

SOIL-FILLED CONTAINER SHELTERS AND OBSERVATION POSTS

5-6. Soil-filled containers can be used to build effective shelters and observation posts. GTA 90-01-011 provides design and construction information for several such structures, including an aboveground 20-foot military van (MILVAN) personnel bunker, a small observation post, and a large observation post. Soil-filled container observation posts are built directly on the ground or on raised structures to provide

protected observation in all directions. They have increased level of survivability over plywood perimeter bunkers (see chapter 4), but require additional engineer effort.

METAL CULVERT SHELTER

5-7. A metal culvert shelter (see figure 5-1) can be quickly constructed aboveground and is intended for use in areas where personnel are billeted or work in conventional nonprotected buildings but need additional survivability in case of attack. They may be placed outside high troop concentration areas such as dining facilities, billeting, or CPs. The shelter is 6 feet high and consists of two rows of 55-gallon drums with a 4-foot span between rows. A 2- by 4-inch stud, measuring 4 inches higher than the drums, is placed inside each drum. The drums are filled with soil. A 2- by 8-inch top plate is connected to the studs lengthwise through the bunker. Six-foot corrugated pipe halves are bolted to the plate and covered with soil and sandbags creating a 2-foot layer. Ends of the position are protected by soil bin walls, soil-filled drums, or other materials. This shelter provides protection against mortars and small-caliber direct-fire weapons.

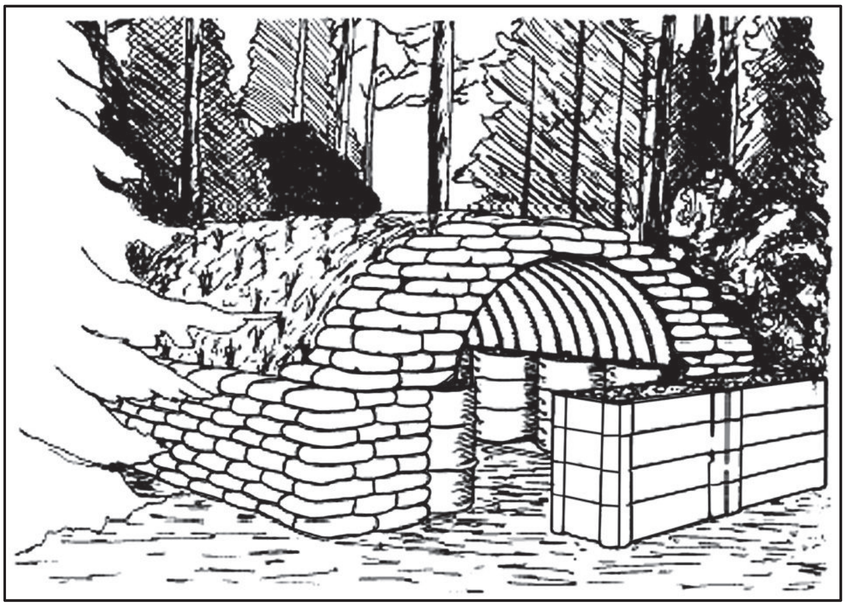

Figure 5-1. Metal culvert shelter

METAL SHIPPING CONTAINER SHELTER

5-8. Large metal shipping containers (such as MILVAN containers) can be used to make effective shelters. These box-shaped containers, with 8-foot long, 6-foot wide, and 6-foot tall internal dimensions, are easily converted into protective CPs, communications shelters, troop shelters, or aid stations (see figure 5-2, page 5-4). The shelter can be constructed aboveground, but it is most effective when constructed belowground and covered with soil and sandbags. When constructing this type of buried shelter, it is critical that the CONEX roof and walls are reinforced to support the weight of the additional load from soil or sandbags. Because the container's floor is stronger than its roof, inverting it will allow the container to better support the overhead cover.

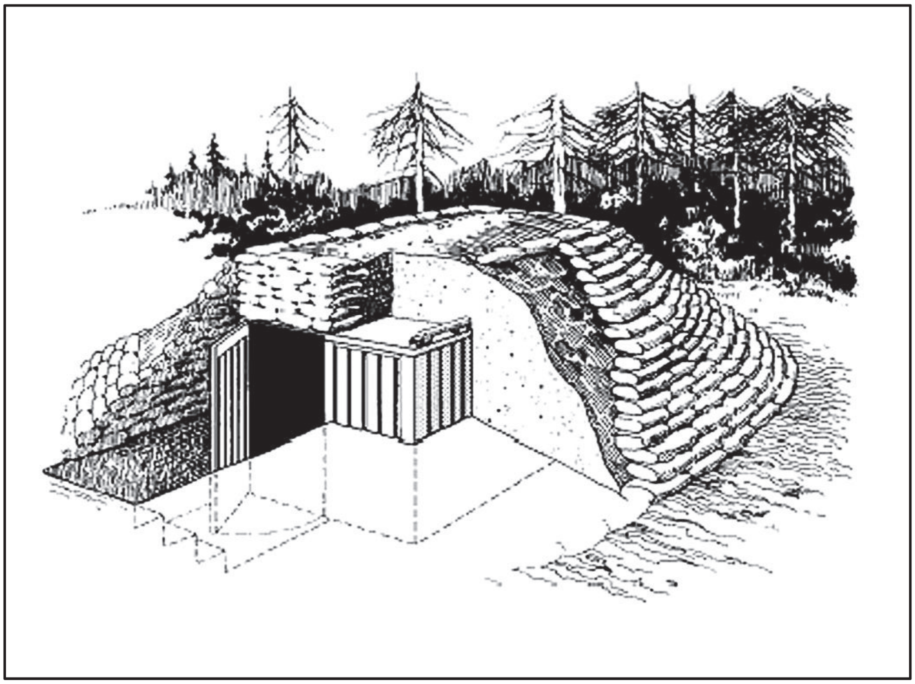

Figure 5-2. Metal shipping container shelter

TIMBER FRAME SHELTERS

5-9. Timber frame shelters are constructed from raw materials or prefabricated sets. They are designed to provide protection from direct-fire weapons and indirect-fire fragmentation. These structures are most effective when constructed belowground, but do not provide adequate protection against direct hits from indirect-fire weapons. Properly constructed overhead cover will shield against contact burst weapons up to 82-millimeter mortars. Figures 5-3, 5-4, and 5-5 depict three examples of timber frame shelters.

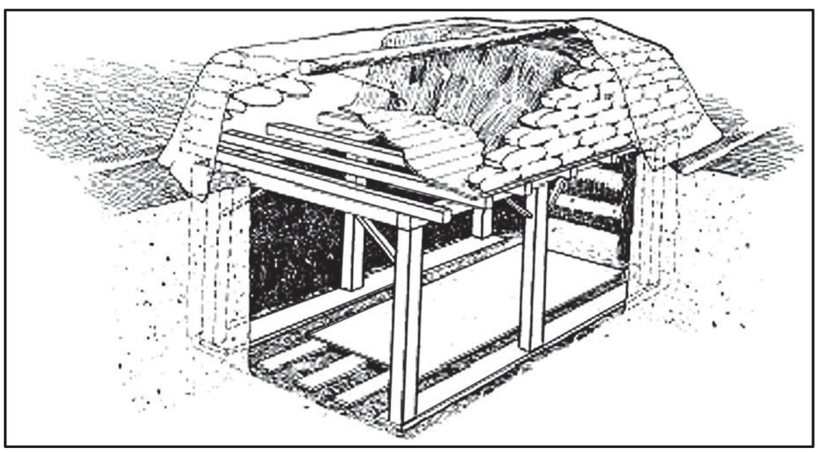

Figure 5-3. Timber post buried shelter

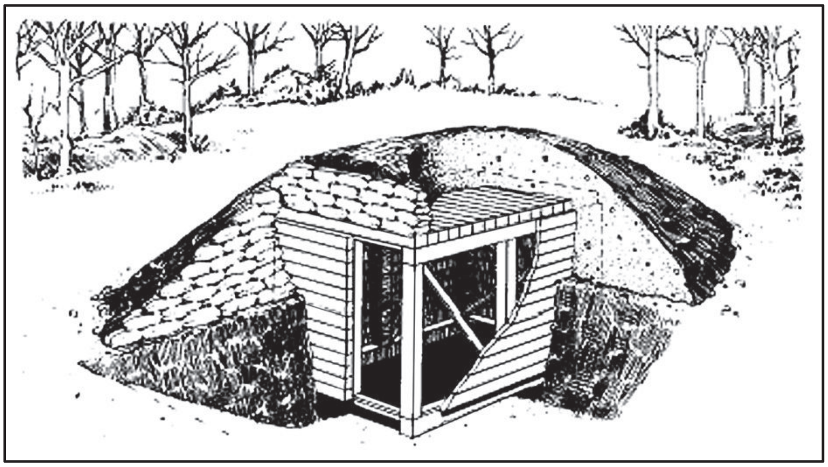

Figure 5-4. Modular timber frame shelter

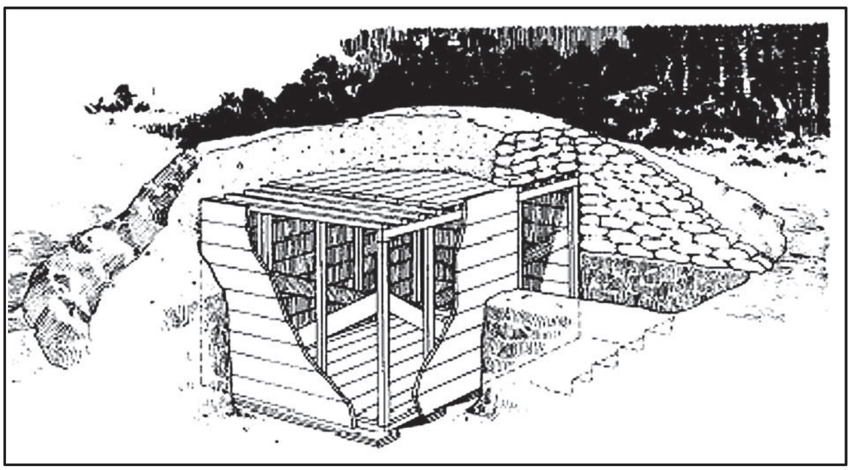

Figure 5-5. Timber frame buried shelter

REHABILITATION AND UPGRADE OF EXISTING STRUCTURES

5-10. When occupying existing structures and buildings in the AO, several measures may be taken to increase survivability of personnel and equipment. Below are proven techniques that will harden permanent buildings. Many techniques discussed previously remain applicable although the sequence of implementation may change depending on the situation and the availability of resources. Commanders should consider these survivability techniques and determine priority of emplacement or implementation. Techniques that will increase hardening of structures include—

- Establishing standoff from the occupied structure.
- Ditching and berming to mitigate blast effects.
- Establishing fighting positions and protective bunkers for personnel.
- Establishing ECPs.
- Covering doors and windows to prevent observation inside the structure and limit entrance of munitions (screens, plywood, and such). In cases where glass windows or doors must remain uncovered, they should be protected with an approved reflective fragment retention film to minimize casualties from flying glass.
- Applying blast protection fabrics and materials to interior walls to mitigate masonry wall fragmentation (such as corrugated metal or geotextile fabric retrofits).

- Constructing predetonation roof and screens.

ACTIVE HARDENING MEASURES

5-11. Active hardening measures are those measures that involve a person or machine taking some action to open, move, lower, or raise the device for it to be effective. These are most often gates, cable-beam barriers, bollards, or vehicles providing protection from attack.

PASSIVE HARDENING MEASURES

5-12. Passive hardening measures are those measures that remain static. These measures are effective without movement and reduce speed, channel traffic, and mitigate blast effects of possible threats. Berms, ditches, concrete walls, and fences are all examples of passive hardening measures. Other types of passive measures include serpentine roadways and other speed reduction devices.

Chapter 6

Camouflage and Concealment

When existing concealment is insufficient, military forces can alter the physical environment to provide or improve concealment for personnel and physical assets. Similarly, they can employ camouflage to confuse, mislead, or evade the enemy. Both of these—camouflage and concealment—comprise one of the four areas of survivability operations described in chapter 1. Camouflage and concealment focus on providing protection from observation and surveillance. This chapter describes types of sensors and principles and considerations for mitigating them. It also provides various techniques for altering the physical environment that can be employed for providing or improving camouflage and concealment.

THREAT OVERVIEW

6-1. Threat forces and elements employ a variety of sensors to detect and identify U.S. Soldiers/Marines, equipment, and supporting installations. These sensors may be visual, near-infrared, infrared, ultraviolet, acoustic, or multispectral/hyperspectral. They may be employed by dismounted personnel or ground-, air-, or space-mounted platforms. Such platforms are often capable of supporting multiple sensors. Friendly troops rarely know all the specific sensor systems or combinations of systems that an enemy employs. Although protection priorities should be based on which sensors an enemy is known to be using, friendly troops should understand and seek to protect against all known threat surveillance systems. This section provides an overview of the various types of sensors, while the rest of this chapter focuses on mitigation techniques that involve altering the physical environment.

DATA COLLECTION

6-2. An enemy collects information about U.S. forces for two basic reasons—target acquisition and intelligence production. Enemy weapons systems often have sensors that locate and identify targets at long ranges in precise detail. Soldiers/Marines and units should take actions to hinder the enemy's target-acquisition process. These actions include all practical camouflage and concealment activities expected to reduce the identification of Soldiers/Marines, units, and facilities.

6-3. An enemy uses sensor systems to locate and identify large Army/Marine Corps formations and headquarters and to predict their future activities. Enemy detection of rear-area activities, such as logistics centers and communications nodes, may also reveal friendly intentions.

6-4. An enemy uses tactical reconnaissance to provide additional information on U.S. forces' dispositions and the terrain in which they are going to operate. The enemy's tactical reconnaissance also attempts to identify targets for later attack by long-range artillery, rockets, aircraft, and ground forces.

SENSOR SYSTEMS

6-5. An enemy uses many different types of electronic surveillance equipment. Sensor systems are classified according to the part of the EM spectrum in which they operate. An enemy uses detection sensors that operate in one of the following two modes:

- **Active.** Active sensors emit energy that reflects from targets and is recaptured by the emitting or other nearby sensor, indicating the presence of a target. Examples of active sensors are searchlights and radar.

- **Passive.** Passive sensors do not emit energy; they collect energy, which may indicate the presence of a target. Examples of passive sensors are the human eye, night vision devices (NVDs), infrared imaging devices, acoustic sensors, and photographic devices.

Visual Sensors

6-6. Visual sensors work in the parts of the EM spectrum that are visible to the human eye. Enemy soldiers' eyes are the principle sensors on a battlefield. They may be aided by binoculars, telescopic sights, and image intensifiers. Civilian populations, enemy agents, reconnaissance teams, and patrols are visual-sensor systems from the enemy's intelligence viewpoint. Three types of enemy visual sensors are—

- **Image intensifiers.** Image intensifiers are passive night-observation devices. They amplify the low-level light that is present on even the darkest nights. These devices are used for surveillance and as weapon sights on small arms and vehicles. Airborne platforms are also capable of supporting image intensifiers.
- **Low-light television.** Low-light television combines image intensification with television technology, and it is usually mounted on airborne platforms.
- **Aerial reconnaissance, remote sensing, and imagery.** Aerial photography, satellite imagery, and video imagery allow image analysts to record and study visual information. These analysts then produce target nomination lists that are, in effect, priority lists of targets in a given target scene. Since analysts often have to make subjective determinations of the identity and/or importance of a given target, the ranking of targets provides the defender with an opportunity to use camouflage and concealment to impact an enemy's target-prioritization process. Video systems allow transmission of visual images to the ground while the manned aircraft, satellite, or unmanned aerial system is still in flight.

Near-Infrared Sensors

6-7. Near-infrared sensors operate at a wavelength immediately above the visible light wavelength of the EM spectrum. Near-infrared energy reflects well from live vegetation but reflects better from dead vegetation and most manmade materials. Near-infrared sensors, such as sights and periscopes, allow the human eye to detect targets based on differences in their reflection of near-infrared energy. Near-infrared sensors are partially blocked by fog, mist, and smoke operations, although not as completely as visual sensors. Enemy combat vehicles use active near-infrared sensors that employ searchlights, scopes, and sights; but these sensors are rapidly being replaced with image intensifiers and thermal gun sights.

Infrared Sensors

6-8. Infrared sensors detect the contrasts in heat energy that targets radiate on the battlefield and display the contrasts as different colors or shades. Because longer wavelength infrared radiation is more susceptible to atmospheric absorption than near-infrared radiation, infrared sensors are less affected by typical concentrations of fog or conventional smoke.

6-9. Differences in thermal mass and surface properties (reflectivity) of manmade and natural materials result in target-to-background contrasts. These contrast levels change dramatically over a daily cycle. For example, operating vehicles and generators, heated buildings and tents, and Soldiers/Marines are usually hotter than their background. Also, equipment exposed to direct sunlight appears hotter than most natural backgrounds. At night, however, equipment might appear cooler than its background if it is treated with special emissivity coatings. In other words, military equipment, particularly metallic equipment, generally heats up and cools off more quickly than its background.

6-10. Sophisticated, passive infrared sensors (such as the forward-looking infrared [FLIR] system) can be mounted on aircraft. FLIR sensors provide aircrews and enemy ground forces with real-time infrared imagery that is displayed on video monitors.

6-11. Reconnaissance aircraft often employ special infrared films to record temperature differences. Due to film processing, however, these systems are subject to time delays in obtaining the data. Newer versions of this sensor produce nonfilm-based images.

Ultraviolet Sensors

6-12. The ultraviolet area is the part of the EM spectrum with wavelengths shorter than visible light, but longer than X-rays. Ultraviolet sensors are more important in snow-covered areas, because snow reflects ultraviolet energy well, and most white paints and manmade objects do not reflect ultraviolet energy very well. Photographic intelligence systems with simple ultraviolet filters highlight military targets as dark areas against snow-covered backgrounds. These backgrounds require specially designed camouflage that provides a high ultraviolet reflectance.

Radar

6-13. Radar uses high-frequency radio waves to penetrate atmospheric impediments such as fog, mist, and smoke. Radar works by transmitting a very strong burst of radio waves and then receiving and processing the reflected waves. In general, metal objects reflect radar waves well, while radar waves are either weakly reflected by or pass through most other objects. The shape and size of a metal object determine the strength of the reflected signal. A large, metal object generally reflects more signal than a small object. Therefore, large, metal objects can be detected from greater distances. The method by which the received radio wave is processed determines the type of radar. Radar systems commonly used against ground forces on the battlefield include—

- **Moving target indicators (MTIs).** When an EM wave hits a moving target, the wave is reflected and changes frequency. The faster the target moves, the larger the changes in frequency. The simplest and most common battlefield radar detects this frequency change. Threat forces use MTIs for target acquisition. More sophisticated developmental radar systems, such as the Joint Surveillance Target Attack Radar System, use airborne surveillance platforms that downlink captured data to ground-station modules in near real time. Ground-based operators are then able to manipulate the data and gain heightened situational information, which is forwarded to enemy command and control nodes to enhance tactical decisionmaking.
- **Imaging radar.** An imaging radar's receiver and processor are so sensitive that an image of the detected target is displayed on a scope. Imaging radar, such as side-looking airborne radar, is generally used on airborne or space-borne platforms. Imaging radar typically does not provide the same resolution as the FLIR systems and is less likely to be used for terminal target acquisition.
- **Countermortar and counterbattery radar.** Countermortar and counterbattery radar usually transmit two beams of energy that sweep above the horizon. An artillery or mortar round or a rocket passing through the beams reflects two signals that are received and plotted to determine the origin of the round.

Acoustic Sensors

6-14. The three predominant types of acoustical detection systems are—

- **The human ear.** Although the human ear is an effective acoustic sensor, visual confirmation is usually preferred.
- **Flash-sound ranging.** Flash-sound ranging is used against artillery. Light travels faster than sound, so enemy sound-ranging teams can determine the distance to a gun tube by accurately measuring the time between seeing a muzzle flash and hearing the sound. If the sound is detected by two or more teams, analysts plot the ranges using automated data-processing computers. The target is located where the plots intersect.
- **Ground-based microphone array.** Ground-based microphone-array systems allow listeners to record acoustic signatures and accurately triangulate their positions.

Radio Sensors

6-15. Threat forces make a great effort to search for, detect, and locate the sources of U.S. radio communications. They use various direction-finding techniques to locate opposing emitters. Once an emitter is detected, an enemy can take a number of actions, including simply intercepting the transmissions,

jamming or targeting the emitter for destruction, and various other electronic warfare actions. (See FM 2-0 and MCWP 2-1 for more information on radio sensors.)

Multispectral and Hyperspectral Imagery Sensors

6-16. Each object or material has a unique spectral signature, often in the portions of the EM spectrum that are not visible to the human eye. Multispectral and hyperspectral imagery capabilities simultaneously collect data in different portions (both visible and nonvisible) of the EM spectrum as described below:

- **Multispectral.** Multispectral imagery capabilities split the EM spectrum into several distinct bands (less than 100). A multispectral imagery sensor simultaneously collects two or more sets of information in different portions of the EM spectrum which are then registered on the same format.
- **Hyperspectral.** Instead of splitting the EM spectrum into several (less than 100) distinct bands, hyperspectral imagery capabilities split it into hundreds of bands. Unlike the current multispectral systems, hyperspectral imagery systems collect continuously across the spectrum. The ability to distinguish between substances based on their reflectance is greatly enhanced with a greater number of bands.

Note. See FM 3-11.50 for more information about sensors and the use of obscurants as countermeasures against them.

Camouflage and Concealment Versus Threat Sensors

6-17. Target acquisition can be accomplished by a variety of sensors that operate throughout the EM spectrum. This poses a challenge in camouflage and concealment planning and employment—determining which enemy sensor(s) the camouflage and concealment activities should be designed to defeat. Unfortunately, no single answer is correct for all situations. Unit commanders without specific guidance from higher echelons assess their tactical situation and plan camouflage and concealment activities accordingly. If intelligence data indicate that an enemy will use visual sensors for reconnaissance and target acquisition, then visual countermeasures must be employed. For infrared or radar sensors, countermeasures that are effective in those spectra must be employed. If a multispectral or hyperspectral threat is anticipated, camouflage and concealment activities are conducted to protect a unit in its most vulnerable EM bandwidths. Very few available camouflage materials or techniques provide complete broadband protection.

PRINCIPLES

6-18. To remain a viable force on the battlefield, units must understand the principles of camouflage and concealment. To design and effectively integrate camouflage and concealment activities, Soldiers/Marines must constantly consider an enemy's point of view. (What will it see? What characteristics will its sensors detect?) Placing a low priority on camouflage and concealment activities because of time constraints, minimal resources, or inconvenience could result in mission failure and unnecessary loss of life. (Appendix F contains more information on other camouflage considerations.)

6-19. The primary goal of camouflage and concealment activities is to avoid enemy detection; however, this is not always feasible. In some cases, camouflage and concealment activities may succeed by merely preventing an enemy from identifying a target. Simply avoiding identification is often sufficient to increase survivability. The principles described in this section have proven effective for avoiding detection and identification.

Identify the Threat

6-20. Obtain as much information as possible about an enemy's surveillance capability. IPB should—

- Include the sensors that an enemy may use in a particular AO.
- Include information on the enemy's tactical employment of the sensors, if possible.

- Assess the impact of the enemy's surveillance potential on the target under consideration. This assessment varies with the relative positions of the sensor and the target on the battlefield, the role of the target, and the physical characteristics of the sensor and the target.

AVOID DETECTION BY ROUTINE SURVEILLANCE

6-21. Sophisticated sensors often have narrow fields of view. Furthermore, sensors can be very expensive and are unlikely to be deployed in such numbers as to enable coverage of the entire battlefield at all times. Sophisticated sensors are most likely to be deployed in those areas where an enemy suspects that friendly targets are deployed. The enemy may suspect that an area contains targets because of detection by less sophisticated, wider-coverage sensors or because of tactical analysis. Therefore, an important aspect of remaining undetected is to avoid detection by routine enemy surveillance.

6-22. Many sensors operate as well at night as they do during the day. Therefore, darkness does not provide effective protection from surveillance. Passive sensors are very difficult to detect, so assume that they are being used at night. Do not allow antidetection efforts to lapse during the hours of darkness. For example, conceal spoil while excavating a fighting position, even at night. Certain types of obscurants will also defeat NVDs.

TAKE COUNTERMEASURES

6-23. In some cases, it might be appropriate to take action against identified enemy sensors. The ability to deploy countermeasures depends on a number of factors—the effective range of friendly weapons, the distance to enemy sensors, and the relative cost in resources versus the benefits of preventing the enemy's use of the sensor. An additional factor to consider is that the countermeasure itself may provide an enemy with an indication of friendly intentions.

EMPLOY REALISTIC CAMOUFLAGE AND CONCEALMENT ACTIVITIES

6-24. The more closely a target resembles its background, the more difficult it is for an enemy to distinguish between the two. Adhering to this fundamental principle of camouflage and concealment requires awareness of the surroundings, proper camouflage and concealment skills, and the ability to identify target EM signatures that enemy sensors will detect.

Visual Sensors

6-25. The most plentiful, reliable, and timely enemy sensors are visual. Therefore, camouflage and concealment techniques effective in the visual portion of the EM spectrum are extremely important. Something that cannot be seen is often difficult to detect, identify, and target. Field uniforms, standard camouflage screening paint patterns, Lightweight Camouflage Screen System (LCSS), and battlefield obscurants are effective camouflage and concealment techniques against visual sensors. Full-coverage camouflage and concealment helps avoid visual detection by the enemy. When time is short, apply camouflage and concealment first to protect the target from the most likely direction of attack and then treat the remainder of the target as time allows.

Near-Infrared Sensors

6-26. Near-infrared sights are effective at shorter ranges (typically 900 meters) than enemy main guns. While red filters help preserve night vision, they cannot prevent near-infrared sensors from detecting light from long distances. Therefore, careful light discipline is an important countermeasure to near-infrared sensors and visual sensors (such as image intensifiers). LCSS, battlefield obscurants, standard camouflage screening paint patterns, and certain uniforms are designed to help defeat near-infrared sensors.

Infrared Sensors

6-27. Natural materials and terrain shield heat sources from infrared sensors and break up the shape of cold and warm military targets viewed on infrared sensors. Do not raise vehicle hoods to break windshield glare

because this exposes a hot spot for infrared detection. Even if the infrared system is capable of locating a target, the target's actual identity can still be disguised. Avoid building unnecessary fires. Use vehicle heaters only when necessary. LCSSs, infrared-defeating obscurants, chemical-resistant paints, and certain uniforms are designed to help break up infrared signatures, but they will not defeat infrared sensors.

Ultraviolet Sensors

6-28. Ultraviolet sensors are a significant threat in snow-covered areas. Winter paint patterns, the arctic LCSS, and terrain masking are critical means for defending against these sensors. Any kind of smoke will defeat ultraviolet sensors. Field-expedient countermeasures, such as constructing snow walls, also provide a means of defeating ultraviolet sensors.

Radar

6-29. An enemy uses MTI, imaging, countermortar, and counterbattery radars. Mission dictates the appropriate defense, while techniques depend on the equipment available.

6-30. MTI radar is a threat to ground forces near a battle area. Radar-reflecting metal on uniforms has been reduced, and Kevlar helmets and body armor are now radar-transparent. Plastic canteens are standard issue, and buttons and other nonmetal fasteners have replaced metal snaps on most field uniforms to minimize their vulnerability to detection by MTI radar.

6-31. Soldiers/Marines carry metal objects (ammunition, magazines, weapons) to accomplish their mission, and most radar can detect these items. Therefore, movement discipline is very important. Moving by covered routes (terrain masking) prevents radar detection. Slow, deliberate movements across areas exposed to radar coverage helps avoid detection by MTI radar.

6-32. Vehicles are large radar-reflecting targets, and a skilled MTI operator can even identify the type of vehicle. Moving vehicles can be detected by MTI radar from 20 kilometers, but travelling by covered routes helps protect against surveillance.

6-33. Imaging radar is not a threat to individual Soldiers/Marines. Concealing vehicles behind earth, masonry walls, or dense foliage effectively screens them from imaging radar. Light foliage may provide complete visual concealment; however, it is sometimes totally transparent to imaging radar. When properly deployed, the LCSS effectively scatters the beam of imaging radar. (See appendix F for more information.)

6-34. Radar is subject to overload. It is very effective and accurate when tracking single rounds; however, it cannot accurately process data on multiple rounds (four or more) that are fired simultaneously. Chaff may also be effective against countermortar and counterbattery radar if it is placed near the radar.

Acoustic Sensors

6-35. Noise discipline defeats detection by the human ear. Pyrotechnics or loudspeakers can screen noise, cover inherently noisy activities, and confuse sound interpretation. However, they may also attract attention—revealing that something is going on—similar to the use of smoke.

6-36. It is possible to confuse an enemy by screening flashes or sounds. Explosives or pyrotechnics, fired a few hundred meters from a battery's position within a second of firing artillery, will effectively confuse sound-ranging teams. Coordinating fire with adjacent batteries (within two seconds) can also confuse enemy sound-ranging teams.

Radio Sensors

6-37. The best way to prevent an enemy from locating radio transmitters is to minimize transmissions, protect transmissions from enemy interception, and practice good radiotelephone-operator procedures. Preplanning message traffic, transmitting as quickly as possible, and using alternate communication means whenever possible ensure that transmissions are minimized. To prevent the enemy from intercepting radio communications, change the radio frequencies and use low-power transmissions, terrain masking, or directional or short-range antennas.

Minimize Movement

6-38. Movement attracts the enemy's attention and produces a number of signatures (tracks, noise, hot spots, dust). In operations that inherently involve movement (such as offensive tasks), plan, discipline, and manage movement so that signatures are reduced as much as possible. (See paragraphs 6-103 through 6-109 for information on disciplined movement techniques.)

Use Decoys

6-39. Use decoys to confuse an enemy. The goal is to divert enemy resources into reporting or engaging false targets. An enemy who has mistakenly identified decoys as real targets is less inclined to search harder for the actual, well-hidden targets. The keys to convincing an enemy that the decoy is the real target are—

- Decoy fidelity (realism), which refers to how closely the multispectral decoy signature represents the target signature.
- Deployment location, which refers to whether or not a decoy is deployed so that the enemy will recognize it as typical for that target type. For example, a decoy tank is not properly located if it is placed in the middle of a lake.

6-40. A high-fidelity decoy in a plausible location often fools an enemy into believing that it has acquired the real target. Deploying low-fidelity decoys, however, carries an associated risk. If an enemy observes a decoy and immediately recognizes it as such, it will search harder for the real target since decoys are generally deployed in the same vicinity as the real targets. Plausible, high-fidelity decoys specifically designed to draw enemy fire away from real targets should be deployed to closely represent the multispectral signatures of the real targets. Properly deployed decoys have been proven in operational employment and experimental field tests to be among the most effective of all camouflage and concealment techniques.

Avoid Operational Patterns

6-41. An enemy can often detect and identify different types of units or operations by analyzing the signature patterns that accompany their activities. For example, an offensive is usually preceded by the forward movement of engineer obstacle-reduction assets, POL, and ammunition. Such movements are very difficult to conceal; therefore, an alternative is to modify the pattern of resupply. An enemy will recognize repetitive use of the same camouflage and concealment techniques.

Apply Recognition Factors

6-42. To camouflage effectively, continuously consider the threat's viewpoint. Prevent patterns in antidetection countermeasures by applying the following recognition factors to tactical situations. These factors describe a target's contrast with its background. If possible, collect multispectral imagery to determine which friendly target signatures are detectable to enemy sensors.

Reflectance

6-43. Reflectance is the amount of energy returned from a target's surface as compared to the energy striking the surface. Reflectance is generally described in the following three ways, according to the part of the EM spectrum in which the reflection occurs:

- Visual reflectance is characterized by the color of a target. Color contrast can be important, particularly at close ranges and in homogeneous background environments such as snow or desert terrain. The longer the range, the less important color becomes. At very long ranges, all colors tend to merge into a uniform tone. Also, the human eye cannot discriminate color in poor light.
- Temperature reflectance is the thermal energy reflected by a target (except when the thermal energy of a target is self-generated, as in the case of a hot engine). Infrared imaging sensors measure and detect differences in temperature-reflectance levels (known as thermal contrast).

- Radar-signal reflectance is the part of the incoming radio waves that is reflected by a target. Radar sensors detect differences in a target's reflected radar return and that of the background. Since metal is an efficient radio-wave reflector and metals are still an integral part of military equipment, radar return is an important reflectance factor.

Shape

6-44. Natural background is random, and most military equipment has regular features with hard, angular lines. Even an erected camouflage net takes on a shape with straight-line edges or smooth curves between support points. An enemy can easily see silhouetted targets, and its sensors can detect targets against any background unless their shape is disguised or disrupted. Size, which is implicitly related to shape, can also distinguish a target from its background.

Shadow

6-45. Shadow can be divided into the following two types:

- **Cast shadow**. A cast shadow is a silhouette of an object projected against its background. It is the more familiar type and can be highly conspicuous. In desert environments, a shadow cast by a target can be more conspicuous than the target itself.
- **Contained shadow**. A contained shadow is the dark pool that forms in a permanently shaded area. Examples are the shadows under the track guards of an armored fighting vehicle, inside a slit trench, inside an open cupola, or under a vehicle. Contained shadows show up much darker than their surroundings and are easily detected by an enemy.

Movement

6-46. Movement always attracts attention against a stationary background. Slow, regular movement is usually less obvious than fast, erratic movement.

Noise

6-47. Noise and acoustic signatures produced by military activities and equipment are recognizable to the enemy. The pitch, loudness, and tone of sounds can be used to identify the nature, origin, and exact location of their sources.

Texture

6-48. A rough surface appears darker than a smooth surface, even if both surfaces are the same color. For example, vehicle tracks change the texture of the ground by leaving clearly visible track marks. This is particularly true in undisturbed or homogeneous environments, such as a desert or virgin snow, where vehicle tracks are highly detectable. In extreme cases, the texture of glass or other very smooth surfaces causes a shine that acts as a beacon. Under normal conditions, very smooth surfaces stand out from the background. Therefore, eliminating shine must be a high priority in camouflage and concealment.

Patterns

6-49. Rows of vehicles and stacks of war materiel create equipment patterns that are easier to detect than random patterns of dispersed equipment. Equipment patterns should be managed to use the surroundings for vehicle and equipment dispersal. However, equipment dispersal should not be implemented in such a way that it reduces a unit's ability to accomplish its mission.

6-50. Equipment paint patterns often differ considerably from background patterns. The critical relationships that determine the contrast between a piece of equipment and its background are the distance between the observer and the equipment and the distance between the equipment and its background. Since these distances usually vary, it is difficult to paint equipment with a pattern that always allows it to blend with its background. As such, no single pattern is prescribed for all situations. Field observations provide the best match between equipment and background.

6-51. The overall terrain pattern and the signatures produced by military activity on the terrain are important recognition factors. If a unit's presence is to remain unnoticed, it must match the signatures produced by stationary equipment, trucks, and other activities with the terrain pattern. Careful attention must also be given to vehicle tracks and their affect on the local terrain during unit ingress, occupation, and egress.

CONSIDER AVOIDANCE IN SITE SELECTION

6-52. Site selection is extremely important because the location of personnel and equipment can eliminate or reduce recognition factors. If a tank is positioned so that it faces probable enemy sensor locations, the thermal signature from its hot engine compartment is minimized. If a vehicle is positioned under foliage, the exhaust will disperse and cool as it rises, reducing its thermal signature and blending it more closely with the background. Placing equipment in defilade (dug-in) positions prevents detection by ground-mounted radar. Many factors govern site selection and should be addressed in a composite fashion.

6-53. The mission is the most important factor in site selection. A particular site may be excellent from a camouflage and concealment standpoint, but the site is useful only if the mission is accomplished. If a site is so obvious that the enemy will acquire and engage a target before mission accomplishment, the site was poorly selected to begin with. Survivability operations are usually a part of most missions, so commanders must first evaluate the worthiness of a site with respect to mission accomplishment and then consider camouflage and concealment.

6-54. Dispersion requirements dictate the size of a site. A site has limited usefulness if it will not permit enough dispersal for survivability and effective operations.

6-55. Every type of terrain, even a flat desert, has a discernible pattern. Terrain features can blur or conceal the signatures of military activity. By using terrain features, camouflage and concealment effectiveness can be enhanced without relying on additional materials. The primary factor to consider is whether using the site will disturb the terrain pattern enough to attract an enemy's attention. The goal is not to disturb the terrain pattern at all. Any change in an existing terrain pattern will indicate the presence of activity. Terrain patterns have distinctive characteristics that are necessary to preserve. The five general terrain patterns are—

- **Agricultural.** Agricultural terrain has a checkerboard pattern when viewed from aircraft. This is a result of the different types of crops and vegetation found on most farms.
- **Urban.** Urban terrain is characterized by uniform rows of housing with interwoven streets and interspersed trees and shrubs.
- **Wooded.** Woodlands are characterized by natural, irregular features, unlike the geometric patterns of agricultural and urban terrains.
- **Barren.** Barren terrain presents an uneven, irregular work of nature without the defined patterns of agricultural and urban areas. Desert environments are examples of barren terrain.
- **Arctic.** Arctic terrain is characterized by snow and ice coverage.

USE CAMOUFLAGE AND CONCEALMENT DISCIPLINE

6-56. Camouflage and concealment discipline avoids activities that change the appearance of an area or reveal the presence of military equipment. Camouflage and concealment discipline is a continuous necessity that applies to every Soldier/Marine. If the prescribed visual and audio routines of camouflage and concealment discipline are not observed, the entire camouflage and concealment effort may fail. Vehicle tracks, spoil, and debris are the most common signs of military activity. Their presence can negate all efforts of proper placement and concealment.

6-57. Camouflage and concealment discipline denies an enemy the indications of a unit's location or activities by minimizing disturbances to a target area. To help maintain unit viability, a unit must integrate all available camouflage and concealment means into a cohesive plan. Camouflage and concealment discipline involves regulating light, heat, noise, spoil, trash, and movement. Successful camouflage and concealment discipline depends largely on the actions of individual Soldiers/Marines. Some of these actions may not be easy on a Soldier/Marine, but failure to observe camouflage and concealment discipline

could defeat an entire unit's camouflage and concealment efforts and possibly impact the unit's survivability and mission success.

6-58. SOPs prescribing camouflage and concealment procedures aid in enforcing camouflage and concealment discipline, and they should—

- List specific responsibilities for enforcing established camouflage and concealment countermeasures and discipline.
- Detail procedures for individual and unit conduct in AAs or other situations that may apply to the specific unit.

6-59. Units should have frequent camouflage and concealment battle drills. Camouflage and concealment discipline is a continuous requirement that calls for strong leadership, which produces a disciplined camouflage and concealment consciousness throughout the entire unit. Appendix E contains additional guidance for incorporating camouflage and concealment into a unit SOP.

Light and Heat Discipline

6-60. Though important at all times, light and heat discipline is crucial at night. As long as visual observation remains a primary reconnaissance method, concealing light signatures remains an important camouflage and concealment countermeasure. Lights that are not blacked out at night can be observed at great distances. For example, the human eye can detect camp fires from 8 kilometers and vehicle lights from 20 kilometers. Threat surveillance can also detect heat from engines, stoves, and heaters from great distances. When moving at night, vehicles in the forward combat area should use ground guides and blackout lights. When using heat sources is unavoidable, use terrain masking, exhaust baffling, and other techniques to minimize thermal signatures of fires and stoves.

Noise

6-61. Individuals should avoid or minimize actions that produce noise. For example, muffle generators by using shields or terrain masking or place them in defilade positions. Communications personnel should operate their equipment at the lowest possible level that allows them to be heard and understood. Depending on the terrain and atmospheric conditions, noise can travel great distances and reveal a unit's position to an enemy.

Spoil

6-62. The prompt and complete policing of debris and spoil is an essential camouflage and concealment consideration. Proper spoil discipline removes a key signature of a unit's current or past presence in an area.

Track

6-63. Vehicle tracks are clearly visible from the air, particularly in selected terrain. Therefore, track and movement discipline is essential. Use existing roads and tracks as much as possible. When using new paths, ensure that they fit into the existing terrain's pattern. Minimize, plan, and coordinate all movement; and take full advantage of cover and dead space.

TECHNIQUES

6-64. Camouflage and concealment is an essential part of tactical operations. It must be integrated into mission variables analyses and the IPB process at all echelons. Camouflage and concealment is a primary consideration when planning operations security (OPSEC). The skillful use of camouflage and concealment techniques is necessary if a unit is to conceal itself and survive. A general knowledge of camouflage and concealment methods and techniques also allows friendly troops to recognize camouflage and concealment better when the enemy uses it. Table 6-1 lists the five general techniques of employing camouflage and concealment—hiding, blending, disguising, disrupting, and decoying.

Table 6-1. Camouflage and concealment techniques

Techniques	Sensor Systems		
	Optical	**Thermal**	**Radar**
Hiding	Earth cover Earth embankments Vegetation LCSS Screens Obscurants	Earth cover Earth embankments Vegetation LCSS Screens Obscurants	Chaff Earth cover Earth embankments Vegetation Nets Radar-absorbing material LCSS
Blending	Paint Foam Lights Vegetation LCSS Textured mats	Thermal paint Foam Air conditioning/heating Vegetation LCSS Textured mats Water Insulation	Vegetation LCSS Radar-absorbing material Reshaping Textured mats
Disguising	Reshaping Paint LCSS	Reshaping Paint	Corner reflectors
Disrupting	Camouflage sails False operating surface Pyrotechnics Smudge pots Balloons Strobe lights Tracer simulators Obscurants	Flares Obscurants	Chaff Corner reflectors
Decoying	Decoy target (pneumatic or rigid structures) Lights Obscurants	Decoy target Flares Air conditioning/heating Obscurants	Decoy target Corner reflectors Signal generators
Legend: LCSS – Lightweight Camouflage Screen System			

HIDING

6-65. This technique screens a target from an enemy's sensors. The target is undetected because a barrier hides it from a sensor's view. Every effort should be made to hide all operations; this includes using conditions of limited visibility for movement and terrain masking. Examples of hiding include—

- Burying mines.
- Placing vehicles beneath tree canopies.
- Placing equipment in defilade positions.
- Covering vehicles and equipment with nets.
- Hiding roads and obstacles with linear screens.
- Using battlefield obscurants, such as smoke.

BLENDING

6-66. This technique alters a target's appearance so that it becomes a part of the background. Generally, it is arranging or applying camouflage material on, over, and/or around a target to reduce its contrast with the background. Characteristics to consider when blending include the terrain patterns in the vicinity and the target's size, shape, texture, color, EM signature, and background. Blending can also be accomplished by terrain mottling which involves scarring the earth with bulldozers to create darker areas on which to place equipment for better blending with the background. (Ensure that mottled areas are irregularly shaped and at least twice the size of the equipment being concealed. Place the equipment off center in the mottled area and drape it with camouflage nets. Dig two to three times as many scars as pieces of equipment being concealed. Doing this prevents the mere presence of mottled areas from giving away a unit's location.)

DISGUISING

6-67. This technique applies materials on a target to mislead the enemy as to its true identity. Disguising changes a target's appearance so that it resembles something of lesser or greater significance. For example, a missile launcher might be disguised to resemble a cargo truck or a large building might be disguised to resemble two small buildings.

DISRUPTING

6-68. This technique alters or eliminates regular patterns and target characteristics. Disrupting techniques include pattern painting, deploying camouflage nets over selected portions of a target, and using shape disrupters (such as camouflage sails) to eliminate regular target patterns.

DECOYING

6-69. This technique deploys a false or simulated target(s) within a target's scene or in a position where the enemy might conclude that it has found the correct target(s). Decoys generally draw fire away from real targets. Depending on their fidelity and deployment, decoys will greatly enhance survivability.

NATURAL CONDITIONS

6-70. Properly using terrain and weather is a first priority when employing camouflage and concealment. Cover provided by the terrain and by conditions of limited visibility is often enough to conceal units. The effective use of natural conditions minimizes the resources and the time devoted to camouflage and concealment. The terrain's concealment properties are determined by the number and quality of natural screens, terrain patterns, and the type and size of targets.

FORESTS

6-71. Forests generally provide the best type of natural screen against optical reconnaissance, especially if the crowns of the trees are wide enough to prevent aerial observation of the ground. Forests with undergrowth also hinder ground observation. Deciduous (leafing) forests are not as effective during the months when trees are bare, while coniferous (evergreen) forests preserve their concealment properties all year. When possible, unit movements should be made along roads and gaps that are covered by tree crowns. Shade should be used to conceal vehicles, equipment, and personnel from aerial observation.

OPEN TERRAIN

6-72. Limited visibility is an especially important concealment tool when conducting operations in open terrain. The threat, however, will conduct reconnaissance with a combination of night-surveillance devices, radar, infrared sensors, and terrain illumination. When crossing open terrain during limited visibility, consider supplementing concealment with smoke—if the risk of it attracting attention is acceptable.

DEAD SPACE

6-73. Units should not locate or move along the topographic crests of hills or other locations where they are silhouetted against the sky. They should use reverse slopes of hills, ravines, embankments, and other terrain features as screens to avoid detection by ground-mounted sensors. IPB concealment and terrain overlays should identify areas of dead space. If overlays are not available, use the LOS method to identify areas of dead space. (See FM 3-25.26 for more details.)

WEATHER

6-74. Conditions of limited visibility (fog, rain, snowfall) hamper reconnaissance by optical sensors. Dense fog is impervious to visible sensors and some thermal sensors, making many threat night-surveillance devices unusable. Dense fog and clouds are impenetrable to thermal sensors (infrared). Rain, snow, and other types of precipitation hinder optical, thermal, and radar sensors.

SMOKE

6-75. Smoke is an effective camouflage and concealment tool when used by itself or with other camouflage and concealment techniques. It can change the dynamics of a battle by blocking or degrading the spectral bands that an enemy's target-acquisition and weapons systems use, including optical and thermal bands. (See FM 3-11.50 for more information on planning smoke operations.)

6-76. Commanders must be able to evaluate natural conditions in their area to effectively direct unit concealment. They must know the terrain and weather conditions before mission execution. In addition to IPB terrain overlays, weather reports, and topographic maps, commanders should use aerial photographs, reconnaissance, and information gathered from local inhabitants to determine the terrain's natural concealment properties.

MATERIALS

6-77. Using natural conditions and materials is the first priority for camouflage and concealment, but using manmade materials can greatly enhance camouflage and concealment efforts. Available materials include pattern-painted equipment, LCSS, radar-absorbing paint, radar-absorbing material, false operating surfaces, vegetation, expedient paint, decoys, and battlefield by-products (construction materials, dirt). (Appendix F lists manmade camouflage and concealment materials that are available through the supply system.)

PATTERN PAINT

6-78. Pattern-painted vehicles blend well with the background and can hide from optical sensors better than those painted a solid, subdued color. Pattern-painted equipment enhances antidetection by reducing shape, shadow, and color signatures. Improved paints also help avoid detection by reducing a target's reflectance levels in the visible and infrared portions of the EM spectrum. The result is a vehicle or an item of equipment that blends better with its background when viewed by threat sensors. While a patterned paint scheme is most effective in static positions, it also tends to disrupt aim points on a moving target. (See appendix F for a list of available paints.)

CAMOUFLAGE NETS

6-79. The LCSS is the standard Army/Marine Corps camouflage net currently available, and it can be ordered through normal unit supply channels (see appendix F). The LCSS reduces a vehicle's visual and radar signatures. Stainless steel fibers in the LCSS material absorb some of the radar signal and reflect most of the remaining signal in all directions. The result is a small percentage of signal return to the radar for detection. The radar-scattering capabilities of the LCSS are effective only if there is at least 2 feet of space between the LCSS and the camouflaged equipment and if the LCSS completely covers the equipment. Do not place a radar-scattering net over a radar antenna because it interferes with transmission. The LCSS is also available in a radar-transparent model.

6-80. The three different LCSS color patterns are desert, woodland, and arctic. Each side of each LCSS has a slightly different pattern to allow for seasonal variations. The LCSS uses modular construction that allows the coverage of various sizes of equipment. (Appendix F discusses the required components and the instructions for assembling LCSS structures for different sizes of equipment.)

VEGETATION

6-81. Use branches and vines to temporarily conceal vehicles, equipment, and personnel. Attach vegetation to equipment with camouflage foliage brackets, spring clips, or expedient means (such as plastic tie-wraps). Use other foliage to complete the camouflage or to supplement natural-growing vegetation. Also use cut foliage to augment other artificial camouflage and concealment materials, such as branches placed on an LCSS to break up its outline. Be careful when placing green vegetation since the underside of leaves presents a lighter tone in photographs. Replace cut foliage often because it wilts and changes color rapidly. During training exercises, ensure that cutting vegetation and foliage does not adversely affect the natural environment (coordinate with local authorities).

6-82. Living vegetation can be obtained in most environments, and its color and texture make it a good blending agent. However, foliage requires careful maintenance to keep the material fresh and in good condition. If branches are not placed in their proper growing positions, they may reveal friendly positions to enemy observers. Cutting large amounts of branches can also reveal friendly positions, so cut all vegetation away from target areas.

6-83. Living vegetation presents a chlorophyll response at certain near-infrared wavelengths. As cut vegetation wilts, it loses color and its near-infrared blending properties, which are related to the chlorophyll response. Replace cut vegetation regularly because over time it becomes a detection cue rather than an effective concealment technique.

6-84. Use dead vegetation (dried grass, hay, straw, branches) for texturing. It provides good blending qualities if the surrounding background vegetation is also dead. Dead vegetation is usually readily available and requires little maintenance; however, it is flammable. Due to the absence of chlorophyll response, dead vegetation offers little camouflage and concealment against near-infrared sensors and hyperspectral sensors operating in the infrared regions.

6-85. When selecting foliage for camouflage and concealment, consider the following:

- Coniferous vegetation is preferred to deciduous vegetation since it maintains a valid chlorophyll response longer after being cut.
- Foliage cut during periods of high humidity (at night, during a rainstorm, or when there is fog or heavy dew) will wilt more slowly.
- Foliage with leaves that feel tough to the fingers and branches with large leaves are preferred because they stay fresher longer.
- Branches that grow in direct sunlight are tougher and will stay fresher longer.
- Branches that are free of disease and insects will not wilt as rapidly.

NONSTANDARD MATERIALS

6-86. Standard-issue camouflage materials (LCSS) are designed to exhibit an artificial chlorophyll response at selected near-infrared wavelengths. Nonstandard materials (sheets, tarps) are not likely to exhibit a chlorophyll response and will not blend well with standard camouflage and concealment material or natural vegetation. Use nonstandard materials only as camouflage and concealment treatments against visual threat sensors, not against near-infrared or hyperspectral threat sensors.

EXPEDIENT PAINT

6-87. Use earth, sand, and gravel to change or add color, provide a coarse texture, simulate cleared spots or blast marks, and create shapes and shadows. Mud makes an excellent field expedient for toning down bright, shiny objects (glass, bayonets, watches). Add clay (in mud form) of various colors to crankcase oil

to produce a field-expedient paint. Table 6-2 provides instructions on how to mix soil-based expedient paints. Use surface soils to mimic natural surface color and reflectivity.

CAUTION

Expedient paint containing motor oil should be used with extreme caution.

Table 6-2. Expedient paints

Paint Materials	*Mixing*	*Color*	*Finish*
Earth, soap, water, soot, paraffin	Mix soot with paraffin, add to a solution of 8 gallons of water and 2 bars of soap, and stir in earth.	Dark gray	Flat, lusterless
Oil, clay, water, gasoline, earth	Mix 2 gallons of water with 1 gallon of oil and ¼ to ½ gallon of clay, add earth, and thin with gasoline or water.	Depends on earth colors	Glossy on metal, otherwise dull
Oil, clay, soap, water, earth	Mix 1½ bars of soap with 3 gallons of water, add 1 gallon of oil, stir in 1 gallon of clay, and add earth for color.	Depends on earth colors	Glossy on metal, otherwise dull
Note. Use canned milk or powdered eggs to increase the binding properties of field-expedient paints.			

RADAR-ABSORBING MATERIAL

6-88. Radar-absorbing material was designed for placement on valuable military equipment. It absorbs radar signals that are transmitted in selected threat wave bands and reduces the perceived radar cross section of the treated equipment. Radar-absorbing material is expensive relative to other camouflage and concealment equipment and is not yet widely available. Radar-absorbing paint offers the same radar cross section reduction benefits as radar-absorbing material, and it is also expensive.

BATTLEFIELD BY-PRODUCTS

6-89. Battlefield by-products (construction materials, dirt) can be used to formulate expedient camouflage and concealment countermeasures. For example, use plywood and two-by-fours to erect expedient target decoys or use dirt to construct concealment berms.

DECOYS

6-90. Decoys are very effective camouflage and concealment tools. The proper use of decoys provides alternate targets against which an enemy will expend ammunition, possibly revealing its position in the process. Decoys also enhance friendly survivability and deceive an enemy about the number and location of friendly weapons, troops, and equipment.

Employment Rationale

6-91. Decoys are used to attract an enemy’s attention for a variety of tactical purposes. Their main use is to draw enemy fire away from critical assets. Decoys are generally expendable, and they—

- Can be elaborate or simple. Their design depends on several factors, such as the target to be decoyed, a unit's tactical situation, available resources, and the time available to a unit for camouflage and concealment employment.
- Can be preconstructed or made from field-expedient materials. Except for selected types, preconstructed decoys are not widely available (see appendix F). A typical Army/Marine Corps unit can construct effective, realistic decoys to replicate its key equipment and features through imaginative planning and a working knowledge of the EM signatures emitted by the unit.

6-92. Proper decoy employment serves a number of tactical purposes, to include—

- Increasing the survivability of key unit equipment and personnel.
- Deceiving the enemy about the strength, disposition, and intentions of friendly forces.
- Drawing enemy fire, which reveals its positions.
- Encouraging the enemy to expend munitions on relatively low-value targets (decoys).

Employment Considerations

6-93. The two most important factors regarding decoy employment are—

- **Location.** Logically placing decoys will greatly enhance their plausibility. Decoys are usually placed near enough to the real target to convince an enemy that it has found the target. However, a decoy must be far enough away to prevent collateral damage to the real target when the decoy draws enemy fire. Proper spacing between a decoy and a target depends on the size of the target, the expected enemy target-acquisition sensors, and the type of munitions directed against the target.
- **Fidelity (realism).** Decoys must be constructed according to a friendly unit's SOP and must include target features that an enemy recognizes. The most effective decoys are those that closely resemble the real target in terms of EM signatures. Completely replicating the signatures of some targets, particularly large and complex targets, can be very difficult. Therefore, decoy construction should address the EM spectral region in which the real target is most vulnerable. The seven recognition factors (see paragraph 6-42) that allow enemy sensors to detect a target are conversely important for decoys. When evaluating a decoy's fidelity, it should be recognizable in the same ways as the real target, only more so. Try to make the decoy slightly more conspicuous than the real target.

CONSIDERATIONS FOR OFFENSIVE TASKS

6-94. Camouflage and concealment countermeasures implemented during offensive tasks attempt to deceive the enemy or prevent it from discovering friendly locations, actions, and intentions or to support a deception plan that may selectively acquire information to support that deception plan. Successful camouflage and concealment contribute to achieving surprise and reduce subsequent personnel and equipment losses. This section addresses considerations for employing camouflage and concealment during offensive tasks. Selected defensive considerations may also apply. (See JP 3-13.4 for additional information on military deception operations.)

PREPARATIONS

6-95. The main camouflage and concealment concern in preparing for offensive tasks is to mask tactical unit deployment. This camouflage and concealment should also be linked to any deception plan that may be part of the operation. While camouflage and concealment are the primary means of masking these activities, deceptive operations frequently achieve, or support, the broader goals of the deception plan.

Signatures

6-96. Offensive tasks create signatures that are detectable to an enemy. Analyzing these signatures may alert an enemy to the nature of an offensive operation (such as planning and location). Commanders at all

levels should monitor operation signatures and strive to conceal them from enemy surveillance. These signatures include—

- Increases in scouting and reconnaissance activity.
- Preparation of traffic routes.
- Forward movement of supplies and ammunition.
- Obstacle breaching activities.
- Preparation and occupation of AAs.
- Preparation and occupation of forward artillery positions.
- Increases in radio communications.
- Changes to the types of equipment within an area.

Assembly Areas

6-97. Prepare AAs during limited visibility. They should then suppress the signatures that their preparations produced and remove any indications of their activities upon mission completion.

6-98. Designate AAs on terrain with natural screens and a developed network of roads and paths. Thick forests and small towns and villages often provide the best locations. If natural screens are unavailable, use spotty sectors of the terrain or previously occupied locations. Place equipment on spots of matching color, and take maximum advantage of artificial camouflage and concealment materials.

6-99. Designate concealed routes for movement into and out of an area. Mask noise by practicing good noise discipline. For instance, tracked movements can be muffled by the thunder of artillery fire, the noise of low-flying aircraft, or the transmission of sounds from broadcast sets.

6-100. Position vehicles to take full advantage of the terrain's natural concealment properties, and cover the vehicles with camouflage nets. Apply paint and cut vegetation to vehicles to enhance camouflage and concealment at AAs and during battle. (When using vegetation for this type of camouflage and concealment treatment, do not cut it from areas close to vehicles.) AAs are particularly vulnerable to aerial detection. Strictly enforce track, movement, and radio discipline. Remove track marks by covering or sweeping them with branches to eliminate or reduce their signature.

6-101. While at an AA, personnel should apply individual camouflage and concealment. Applying stick paint and cut vegetation enhances camouflage and concealment during all phases of an operation.

Decoys

6-102. An enemy may interpret decoy construction as an effort to reinforce a defensive position. Laying false minefields and building bunkers and positions can conceal actual offensive preparations and give the enemy the impression that defenses are being improved. If necessary, conduct engineer preparation activities on a wide front so that the area and direction of the main attack are not revealed.

MOVEMENT

6-103. Move troops, ammunition, supplies, and engineer breaching equipment forward at night or during limited visibility. Although an enemy's use of radar and infrared aerial reconnaissance hinders operations at night, darkness remains a significant concealment tool. Select routes that take full advantage of the terrain's screening properties. Commanders must understand how to combine darkness and the terrain's concealing properties to conceal troop and supply movements.

6-104. When conducting a march, convoy commanders must strictly enforce blackout requirements and the order of march. Guidelines concerning lighting, march orders, and other requirements are usually published in SOPs or operation orders (OPORDs). Required lighting conditions vary depending on the type of movement (convoy versus single vehicle) and a unit's location within the AO. Inspect each vehicle's blackout devices for proper operation.

6-105. Enemy aerial reconnaissance usually focuses on open and barely passable route sectors. When on a march, vehicles should pass these types of sectors at the highest possible speeds. If prolonged delays result

from encountering an unexpected obstacle, halt the column and disperse into the nearest natural screens. During a movement, if a vehicle breaks down and cannot be immediately recovered, push it off the road and conceal it until it can be recovered.

6-106. When conducting a march during good visibility, consider movement by infiltration (single or small groups of vehicles released at different intervals). Movement in stages, from one natural screen to the next, will further minimize possible detection. Use obscurant screens at critical crossings and choke points. While these won't necessarily conceal an event, they will support obscuration and reduce enemy targeting acquisition.

6-107. During brief stops, quickly disperse vehicles under tree crowns or other concealment along the sides of the road. Strictly enforce camouflage and concealment discipline. Watch for glare from vehicle windshields, headlights, or reflectors, and remedy the situation if it does occur. Try to control troop movement on the road or in other open areas. Conduct reconnaissance to select areas for long halts. The reconnaissance party should select areas that are large enough to allow sufficient camouflage, concealment, and dispersion. The quartering party should predetermine vehicle placement, develop a vehicle circulation plan, and guide vehicles into suitable and concealed locations. The first priority, however, is to move vehicles off the road as quickly as possible, even at the expense of initial dispersion. Use camouflage nets and natural vegetation to enhance concealment, and carefully conceal dug-in positions.

6-108. Traffic controllers have a crucial role in enforcing convoy camouflage and concealment. Commanders should issue precise instructions for traffic controllers to stop passing vehicles and have the drivers correct the slightest violation of camouflage and concealment discipline. Convoy commanders are responsible for the convoy's camouflage and concealment discipline. (For information about traffic operations, see ATTP 3-90.4/MCWP 3-17.8.)

6-109. Pass through friendly obstacles at night, in fog, or under other conditions of poor visibility. Also, selectively use smoke (or other obscurant) screens because these poor visibility conditions will not protect against many types of threat sensors. Lay smoke on a wide front, several times before actually executing the passage of lines. Doing this helps deceive an enemy about the time and the specific point of an attack. Conceal lanes through obstacles from the enemy's view to affect targeting capabilities.

OFFENSIVE BATTLE

6-110. Units should adapt to the terrain during a battle. Deploying behind natural vegetation, terrain features, or manmade structures maximizes concealment from enemy observation and provides cover from some direct and indirect systems. Make optimum use of concealed routes, hollows, gullies, and other terrain features that are dead-space areas to enemy observation and firing positions. A trade-off, however, often exists in terms of a slower rate of movement when using these types of routes. In a tactical sense, slower movement may actually support a more rapid tempo of operations.

6-111. Movement techniques emphasizing fire and maneuver help limit enemy observation and targeting accuracy. Avoid dusty terrain because clouds of dust will alert an enemy to the presence of friendly units. However, if the enemy is aware of a unit's presence, dust can be an effective means of obscuring the unit's intentions, and obscuring an enemy's targeting, in the same fashion as smoke. When natural cover and concealment are unavailable or impractical, the coordinated employment of obscurants, suppressive fires, speed, and natural limited-visibility conditions minimize exposure, avoid enemy kill zones, and limit the effectiveness of enemy EAs. However, offensive tasks under these conditions present unique challenges to training and the mission command/command and control warfighting function since dust and smoke affect all participants.

6-112. Breaching operations require concealing the unit that is conducting the breach. Use conditions of poor visibility, and plan the use of obscurants and suppressive fires to screen breaching operations.

6-113. Deliberate gap crossings are uniquely difficult and potentially hazardous. Plan the coordinated use of terrain masking, obscurants, decoys, and deceptive operations to ensure successful crossings. (See ATTP 3-90.4/MCWP 3-17.8 for additional information about gap crossings.)

CONSIDERATIONS FOR DEFENSIVE TASKS

6-114. Successful camouflage and concealment during defensive tasks requires strong emphasis on OPSEC. Proper OPSEC denies an enemy information about a friendly force's defensive preparations. Particularly important is the counterreconnaissance battle, where defensive forces seek to blind an enemy by eliminating its reconnaissance forces. The winner of this preliminary battle is often the winner of the main battle. Camouflage and concealment activities, by virtue of their inherent role in counterefforts, play an important role in both battles. This section addresses considerations for employing camouflage and concealment during defensive tasks. Some of the considerations for offensive tasks may also apply.

PREPARATIONS

6-115. The purpose of camouflage and concealment activities during defensive preparations is to mask key or sensitive activities. Successful camouflage and concealment of these preparations leads to an enemy force that is blinded or deceived and therefore more easily influenced to attack into the strengths of the defense. These key activities include—

- Preparing survivability positions (primary, alternate, and subsequent) and constructing obstacles (for example minefields, tank ditches, and abatis).
- Preparing reserve and counterattack forces' locations and routes (potentially concealed).
- Establishing critical CPs.

Signatures

6-116. A number of signatures may indicate the intentions of friendly defensive preparations, and an enemy analyzes these signatures to determine the defensive plan. Specific signatures that could reveal defensive plans include—

- Working on survivability positions.
- Emplacing minefields and other obstacles.
- Moving different types of combat materiel into prepared positions.
- Preparing routes and facilities.
- Constructing strong points or hardened artillery positions.
- Conducting rehearsals.

Counterattack and Reserve Forces

6-117. Due to the similarity of missions, the concerns for concealing counterattack and reserve forces are similar to those of maneuver forces engaged in offensive tasks. The previous section (beginning at paragraph 6-94) discusses considerations about AAs, troop and supply movements, passages of lines, and deception operations. This information is also useful as a guide when planning camouflage and concealment for a counterattack.

Planning

6-118. Proper planning is essential to minimize or avoid threat detection and prevent successful enemy analysis of the engineer efforts that are integral to defensive preparations. Engineer equipment creates significant signatures, so minimize its use to a level that is commensurate with available time and manpower. Disperse engineer equipment that is not required at the job site. Complete as much work as possible without using heavy equipment, and allow heavy equipment on-site only when necessary. Engineers should minimize their time on-site by conducting thorough, extensive planning and preparation. Additional signatures include—

- Supplies, personnel, and vehicles arriving to and departing from the unit area.
- Survivability positions being constructed or routes being prepared.
- Smoke and heat emitting from kitchens, fires, or stoves.
- Communications facilities being operated.

- Educational and training exercises being conducted.

Movement

6-119. Reserve forces should move along preplanned concealed routes. They should also move and occupy selected locations at night or during other conditions of limited visibility. Quartering parties should preselect individual positions and guide vehicles and personnel to assigned locations. Light, noise, and track discipline are essential; but they are difficult to control during this phase. The quartering party should also develop a traffic-flow plan that minimizes vehicle and troop movement to and from the unit area.

6-120. Arriving units should immediately begin to conceal their positions. Commanders should detail the priorities for camouflage and concealment activities in the OPORD, based on their assessment of which signatures present the greatest opportunity for threat detection.

Assembly Areas

6-121. While AA actions are similar to those of counterattack and reserve positions, the latter positions are more likely to be occupied longer. Therefore, camouflage and concealment needs are more extensive and extended for counterattack and reserve forces. In fact, their camouflage and concealment operations are often indistinguishable from those of support units.

6-122. Counterattack and reserve forces awaiting employment should capitalize on the time available to conduct rehearsals. While essential, these activities are prone to detection by an enemy’s sensors so observe camouflage and concealment discipline at all times and locations. Rehearsals may even support the deception plan.

Placement And Dispersal

6-123. Site selection is crucial when concealing engineer effort. Proper placement and dispersal of equipment and operations are essential. Use natural screens (terrain masking) or urban areas to provide concealment for counterattack and reserve forces. When using forests as natural screens, carefully consider factors such as the height and density of vegetation, the amount and darkness of shadows cast by the screen, and the appropriateness of the particular screen for the season. The condition and quality of natural screens have a decisive effect on the capability to conceal units. Commanders should evaluate natural screens during engineer reconnaissance missions and conduct the missions on a timely, extensive basis.

6-124. The probability of detection increases considerably when survivability positions are prepared. Detection is easier due to the increased size of the targets to be concealed, the contrasting upturned soil, and the difficulty of concealing survivability efforts. Despite these considerations, the enhanced protection afforded by survivability positions usually dictates their use. To minimize the probability of detection, employ a combination of natural screens and overhead nets to conceal construction sites.

Camouflage Nets

6-125. Use camouflage nets (LCSS) to conceal vehicles, tents, shelters, and equipment. Use vegetation to further disrupt the outline of the target rather than completely hide it. Ensure that vegetation is not removed from a single location, because it could leave a signature for threat detection. Gather vegetation sparingly from as many remote areas as possible. This technique allows the immediate area to remain relatively undisturbed.

Stoves And Fires

6-126. Strictly control the use of stoves and fires because they produce visual and thermal signatures detectable to threat sensors. If fires are necessary, permit them only during daylight hours and place them in dead ground or under dense foliage. Use nets and other expedient thermal screens to dissipate rising heat and reduce the fire’s thermal signature.

Camouflage and Concealment Discipline

6-127. Strict camouflage and concealment discipline allows the continued concealment of a unit's position. The longer a unit stays in one location, the harder it is for it to maintain camouflage and concealment discipline. Extended encampments require constant command attention to camouflage and concealment discipline. The evacuation of an area also requires camouflage and concealment discipline to ensure that evidence (trash, vehicle tracks) is not left for enemy detection.

SURVIVABILITY POSITIONS AND OBSTACLES

6-128. Survivability positions include fighting positions, protective positions (shelters), and trench-work connections. Such positions are usually constructed of earth and logs but may also be composed of manmade building materials such as concrete.

Placement

6-129. Properly occupying positions and placing obstacles are critical camouflage and concealment considerations. When possible, place obstacles and occupy positions out of the direct view of threat forces (such as a reverse-slope defense), at night, or under conditions of limited visibility.

Backgrounds

6-130. Select backgrounds that do not silhouette positions and obstacles or provide color contrast. Use shadows to hinder an enemy's detection efforts. If possible, place positions and obstacles under overhead cover, trees, or bushes or in any other dark area of the terrain. This technique prevents the disruption of terrain lines and hinders aerial detection. Camouflage and concealment activities, however, should not hinder the integration of obstacles with fires.

6-131. When using the terrain's natural concealment properties, avoid isolated features that draw the enemy's attention. Do not construct positions directly on or near other clearly defined terrain features (tree lines, hedge rows, hill crests). Offsetting positions into tree lines or below hill crests avoids silhouetting against the background and also counters enemy fire.

Natural Materials

6-132. Use natural materials to supplement artificial materials. Before constructing positions and obstacles, remove and save natural materials (turf, leaves, humus) for use in restoring the terrain's natural appearance for deception purposes. During excavation, collect spoil in carrying devices for careful disposal. When preparing survivability positions and obstacles—

- Avoid disturbing the natural look of surroundings. Use camouflage nets and natural vegetation to further distort the outline of a position, to hide the bottom of an open position or trench, and to mask spoil used as a parapet. To further avoid detection, replace natural materials regularly or when they wilt or change color.
- Consider the effect of backblasts from rocket launchers, missile systems, and AT weapons. Construct a concealed open space to the position's rear to accommodate backblasts. A backblast area should not contain material that will readily burn or generate large dust signatures.
- Use natural materials to help conceal machine-gun emplacements. Machine guns are priority targets, and concealing them is an essential combat task. Although camouflage and concealment is important, placement is the primary factor in concealing machine guns.
- Place mortars in defilade positions. Proper placement, coupled with the use of artificial and natural camouflage and concealment materials, provides the maximum possible concealment. Also consider removable overhead concealment.
- Use decoy positions and phony obstacles to draw enemy attention away from actual survivability positions and traces of obstacle preparation. Decoys serve the additional function of drawing enemy fire, allowing easier targeting of an enemy's weapons systems.

DEFENSIVE BATTLE

6-133. Camouflage and concealment activities during the defensive battle are essentially the same as for the offensive battle. While a majority of the battle is normally fought from prepared, concealed positions, defensive forces still maneuver to prevent enemy breakthroughs or to counterattack. When maneuvering, units should—

- Adapt to the terrain.
- Make optimum use of concealed routes.
- Preselect and improve concealed routes to provide defensive forces with a maneuver advantage.
- Make optimum use of low visibility conditions.
- Plan battlefield obscuration operations, as appropriate, to provide additional concealment for maneuvering forces.

CONSIDERATIONS FOR STABILITY OR DEFENSE SUPPORT OF CIVIL AUTHORITIES TASKS

6-134. The threat of terrorist attack faces all military forces, including those conducting stability tasks or defense support of civil authorities. In addition, forces conducting stability or defense support of civil authorities tasks may also simultaneously conduct offensive or defensive tasks (or both) in the same AO. As a result, camouflage and concealment must not be ignored during stability or defense support of civil authorities tasks. Camouflage and concealment during such tasks draw from the considerations for both offensive and defensive tasks, but will typically draw more heavily from the considerations associated with defensive tasks. Stability or defense support of civil authorities tasks may involve a higher number of relatively fixed sites, such as base camps, which are addressed below (see paragraph 6-139).

PLANNING FOR CAMOUFLAGE AND CONCEALMENT

6-135. No single solution exists for enhancing the survivability of critical assets with camouflage and concealment (except for large-area smoke screens). The characteristics of many such targets are unique and require the creative application of camouflage and concealment principles and techniques. Therefore, the guidelines for camouflage and concealment presented in this section are not intended to impose a regimen that must be followed at all costs. Rather, it suggests a logical sequence that has proven successful over time. In fact, the steps outlined below often lead to creative camouflage and concealment solutions simply because they allow designers to consider the many options, benefits, and pitfalls of camouflage and concealment employment. No camouflage and concealment plan is wrong if it achieves the intended signature-management goals and does not impair mission accomplishment.

PLANS

6-136. Commanders should develop their unit's camouflage and concealment plan based on an awareness, if not a comprehensive assessment, of the detectable EM signatures emitted by forces in his AO. They should evaluate these signatures by considering the enemy's expected intelligence, surveillance, and reconnaissance capabilities (airborne and ground-based), knowledge of the target area, and weapons-on-target capability.

OBJECTIVE

6-137. A camouflage and concealment plan increases survivability within the limits of available resources. Planners must systematically determine which features of a given asset are conspicuous, why those features are conspicuous, and how camouflage and concealment principles and techniques can best eliminate or reduce signatures. Camouflage and concealment should decrease the effectiveness of enemy attacks by interfering with its target-acquisition process, which in turn increases survivability.

PLANNING STEPS

6-138. The steps outlined below provide guidance for designing camouflage and concealment plans for critical assets. The detailed planning approach is applicable in any situation where camouflage and concealment employment is necessary, but more so when the plans include critical assets.

- **Step 1.** Identify the threat. Identify the principal threat sensors, weapon-delivery platforms, and likely directions of attack.
- **Step 2.** Identify critical assets. Include those that are critical from an operational standpoint and those that may provide reference points (cues) for an attack on more lucrative targets.
- **Step 3.** Evaluate critical assets. Once the critical assets are identified, focus efforts on identifying the features of each asset that might be conspicuous to enemy sensors. Consider multispectral (visual, thermal, near–infrared, radar) signatures in this assessment. The recognition factors (see paragraph 6-42) are an excellent framework for conducting this assessment. Include a review of area maps, site plans, photographs, and aerial images of the area. Look at the assets from the enemy's point of view.
- **Step 4.** Quantify signatures. Quantify the multispectral signatures that are emitted by critical assets. Base the quantification on actual surveys, using facsimiles of threat sensors when possible. Specify the EM wavelengths in which critical assets are most vulnerable, and develop signature-management priorities.
- **Step 5.** Establish camouflage and concealment goals. Establish specific camouflage and concealment goals for critical assets. These goals should indicate the signature reduction (or increase) desired and the resources available for camouflage and concealment implementation. Base these goals on the results of steps 1 through 4. Change the camouflage and concealment goals as planning progresses and reiterate them accordingly.
- **Step 6.** Select materials and techniques. Select camouflage and concealment materials and techniques that best accomplish signature-management goals within logistical, maintenance, and resource constraints. Expedient, off-the-shelf materials and battlefield by-products are not identified in this manual, but they are always optional camouflage and concealment materials.
- **Step 7.** Organize the plan. Develop a camouflage and concealment plan that matches goals with available materials, time and manpower constraints, and operational considerations. If the goals are unobtainable, repeat steps 5 and 6 until a manageable plan is developed.
- **Step 8.** Execute the plan. Once a feasible camouflage and concealment plan is developed, execute it. Store temporary or expedient materials inconspicuously. Conduct deployment training on a schedule that denies enemy intelligence teams the opportunity to identify countermeasures or develop methods to defeat the camouflage and concealment.
- **Step 9.** Evaluate the camouflage and concealment. The final step in camouflage and concealment planning is to evaluate the deployed camouflage and concealment materials and techniques. Again, attempt to look at it from an enemy's point of view. Important questions to ask in this evaluation include the following:
  - Does camouflage and concealment increase the survivability of critical assets?
  - Does deployed camouflage and concealment meet the signature-management goals outlined in the plan?
  - Is deployed camouflage and concealment operationally compatible with the treated asset(s)?
  - Are camouflage and concealment materials and techniques maintainable within manpower and resource constraints?

FIXED ASSETS

6-139. Fixed (or relatively fixed) assets such as base camps, airfields, some CPs, warehouses, roadways, pipelines, railways, and other LOC facilities, provide scarce, nearly irreplaceable functional support to ground maneuver forces. The threat to these facilities is both ground-based and aerial. The camouflage and concealment techniques for the two attack types do not necessarily change, but the defender must be aware of the overall implications of his camouflage and concealment plan.

GROUND ATTACKS

6-140. Ground attacks against fixed assets (enemy offensives, terrorist attacks, and enemy special-force incursions) require constant operational awareness by the defenders. While most camouflage and concealment techniques are conceptually designed to defend against an aerial attack, these same techniques can affect the target-acquisition capabilities of an enemy's ground forces to the benefit of the defender. Standard camouflage screening paint patterns, LCSS, and natural vegetation provide camouflage and concealment against a ground attack.

6-141. Camouflage and concealment discipline (light, noise, spoil) involves prudent operational procedures that friendly troops should observe in any tactical situation, particularly in the presence of hostile ground forces. (See paragraph 6-56 for more information.)

AERIAL ATTACKS

6-142. Fixed assets are susceptible to aerial attacks because of their long residence time and immobility. However, fighter-bomber and helicopter aircrews face unique target-acquisition problems due to the relatively short time available to locate, identify, and lock onto targets. Fighter-bombers typically travel at high speeds, even during weapons delivery. This means attacking aircrews have limited search time once they reach the target area. Helicopters travel at slower speeds but generally encounter similar time-on-target limitations. Because of lower flying altitudes and slower speeds, helicopters are more vulnerable to ground defenses. In either case, proper camouflage and concealment can increase aircrew search time, thereby reducing available time to identify, designate, and attack targets. The longer an aircrew is forced to search for a target in a defended area, the more vulnerable the aircraft becomes to counterattack.

ENEMY INTELLIGENCE

6-143. The location and configuration of most fixed assets are usually well known. Camouflage and concealment techniques that protect against sophisticated surveillance sensor systems, particularly satellite-based systems, can be costly in terms of manpower, materials, and time. Steps can be taken to reduce an enemy's detection of relocatable assets, but fixed assets are difficult to conceal from sensors due to the relatively long residence time of fixed versus relocatable assets. Unless the construction process for a given fixed asset was conducted secretly, defenders can safely assume that enemy sensors have previously detected and catalogued its location. Defenders can further assume that attacking forces have intelligence data leading them to the general area of the fixed asset. Camouflage and concealment design efforts, therefore, should focus on the multispectral defeat or impairment of the enemy's local target-acquisition process.

CAMOUFLAGE AND CONCEALMENT TECHNIQUES

6-144. Selected camouflage and concealment techniques should capitalize on terrain features that are favorable to the defender and on the short time available to attacking aircrews for target acquisition. Use artificial and natural means to camouflage the asset. Where time and resources allow, deploy alternative targets (decoys) to draw the attention of the attacking aircrews away from the fixed asset.

6-145. Comprehensive camouflage and concealment designs and techniques for fixed assets can be costly, yet field tests have shown that simple, expedient techniques can be effective. Fixed assets should be supplied with artificial camouflage and concealment materials, and camouflage and concealment principles should be used to increase their survivability.

OTHER CONSIDERATIONS

6-146. While standard camouflage and concealment materials are designed to enhance fixed asset survivability, they have practical limitations that are not easily overcome. Materials applied directly to a fixed asset may achieve the signature-management goals stated in the camouflage and concealment plan. However, if other features in the vicinity are not treated accordingly, the asset may be well hidden but remain completely vulnerable.

6-147. For example, three weapons storage-area igloos are in a row. The middle igloo is treated with camouflage and concealment materials while the other two are not. The middle igloo will still be vulnerable. The enemy knows that three igloos exist and will probably locate the middle one no matter how well the camouflage and concealment plan is designed. However, if all three igloos are treated with camouflage and concealment materials and three decoy igloos are placed away from them, the treated igloos' survivability will increase.

6-148. Furthermore, if a manmade object (traffic surface) or a natural feature (tree line) is close to the igloos, attacking forces will use these cues to proceed to the target area even if all three igloos are treated with camouflage and concealment materials. Remember, a target is part of an overall target scene and an attacker must interpret the scene. Do not make his task easy. Camouflage and concealment plans that treat only the fixed asset and ignore other cues (manmade or natural) within the target scene are insufficient.

RELOCATABLE ASSETS

6-149. Examples of valuable relocatable assets include CPs, theater missile defense units (Patriot batteries), refuel-on-the-move sites, and forward arming and refueling points (FARPs). These assets are critical to offensive and defensive tasks, and their protection should receive a high priority.

MOBILITY AND CAMOUFLAGE AND CONCEALMENT

6-150. Mobility and camouflage and concealment enhance the survivability of relocatable assets. A camouflage and concealment plan must include the techniques for units to deploy rapidly and conduct mobile operations continuously. The camouflage and concealment techniques available to mobile assets are basically the same as for fixed assets, and the principles of camouflage and concealment still apply. However, the mission of relocatable assets differs from that of fixed assets so camouflage and concealment execution also differs.

6-151. Relocatable assets spend from a few hours to several weeks in the same location, depending on their tactical situation. Camouflage and concealment techniques must be planned accordingly. If a unit is at a location for a few hours, it should employ expedient camouflage and concealment techniques. If a unit is at a location for several days, it should employ robust camouflage and concealment plans. The resources a unit expends on camouflage and concealment execution must be weighed against the length of time that it remains in the same location. As camouflage and concealment plans increase in complexity, subsequent assembly and teardown times also increase.

BUILT-IN CAPABILITIES

6-152. Camouflage and concealment should be built into systems to the maximum extent possible. Supplemental camouflage and concealment is usually necessary and should be designed to enhance the built-in camouflage and concealment. Apply the same rules for avoiding detection and the same considerations regarding the recognition factors that are discussed above. The camouflage and concealment planning steps outlined above also apply.

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Chapter 7
Critical Assets

Certain assets should be protected because they are of such extraordinary importance that their loss or degradation would have a significant and debilitating effect on operations or the mission. Although the list of such assets—the critical asset list—will vary in each situation, it typically includes such things as weapon systems, CPs, logistics sites, aviation sites, and base camps. The techniques addressed in previous chapters focused on providing or improving cover, camouflage, and concealment for personnel and various weapon systems. This chapter provides cover, camouflage, and concealment considerations for some other typical critical assets—CPs, logistics sites, and aviation sites. (Since base camps usually contain one or more of these assets, the considerations in this chapter usually apply to base camps. GTA 90-01-011 also provides detailed information.)

COMMAND POSTS

7-1. CPs contain vital systems for the mission command/command and control warfighting function and provide military leaders with the capability to make timely decisions, communicate the decisions to subordinate units, and monitor the execution of the decisions. Initially, CPs will rely on mobility and camouflage and concealment for survivability. Additional measures such as cover and concealment or shielding by terrain features or urban structures will also be considered. Protection can be provided by earth berms, sandbags, soil-filled containers, and concrete barriers. CPs may also use existing hardened facilities or other constructed shelters. When available, supporting engineer units most commonly use berms to increase CP survivability. Berms can be quickly constructed and provide excellent survivability enhancement to CPs, especially as initial measures.

SIGNATURES

7-2. Since World War II, the size and complexity of CPs have increased dramatically. Their signatures have correspondingly increased from a physical and communications perspective (more types of antennas and transmission modes at a wider range of frequencies). As a result, the enemy has more conspicuous signatures available to detect and target CPs for attack. CPs require excellent camouflage and concealment to survive on the battlefield.

7-3. CPs are frequently located near road or rail junctions, or potentially along a LOC and often require new access and egress routes. Consider the following regarding camouflage and concealment for CPs:

- **Vehicle traffic.** When evaluating EM signatures that CPs emit, consider concentrations of vehicles, signs of heavy traffic (characteristic wear and track marks), and air traffic as issues that must be addressed. Park vehicles and aircraft a significant distance from CPs.
- **Antennas.** Antennas and their electronic emissions and numerous support towers are common to most CPs. Paint antennas and support equipment with nonconductive green, black, or brown paint if the surfaces are shiny. If tactically feasible, use remote antennas to reduce the vulnerability of the radio system to collateral damage.
- **Security emplacements.** Security measures (barbed wire, barriers, security and dismount points, and other types of emplacements) can indicate CP operations. Barbed wire exhibits a measurable radar cross section at radar frequencies. Ensure that barbed wire and concertina wire follow natural terrain lines and are concealed as much as possible to reduce its signature.

7-4. Power generators and other heat sources produce signatures that an enemy's surveillance and target-acquisition sensors can detect. Place heat-producing equipment and other thermal sources in defilade positions, within structures, or under natural cover. Heat diffusers, which tone down and vent vehicle exhaust away from threat direction, are an expedient means of thermal-signature reduction.

7-5. Defensive positions often create scarred earth signatures and detectable patterns due to earth excavation. While of obvious value to CP survivability, their signature needs to be mitigated, and requirements can be reduced through the use of natural cover and concealment.

CAMOUFLAGE AND CONCEALMENT

7-6. Camouflage and concealment improves OPSEC and increases survivability by minimizing the observable size and EM signatures of CPs. CP camouflage and concealment requires reconnaissance, planning, discipline, security, and maintenance. Carefully controlled traffic plans decrease the possibility of disturbing natural cover and creating new, observable paths. Decoys may be highly effective means of confusing the enemy's target-acquisition process, particularly against airborne sensors. Against ground threats, the same general rules of camouflage and concealment discipline apply. However, reconnaissance and heightened security patrols enhance camouflage and concealment efforts by denying access to vantage points from which a CP can be observed.

SITES

7-7. Although CPs may change sites every 24 hours, they may be occupied for a longer period than larger AAs. CP site selection is crucial, therefore units should—

- Consider the needs of supporting an extended occupation while minimizing changes to natural terrain patterns. When constructing defensive positions, minimize earth scarring as much as possible. If scarred earth is unavoidable, cut vegetation, use toned-down agents (paint), and apply camouflage nets to help conceal scarred areas.
- Use existing roads and trails. In some cases locating along a LOC may be useful to hide traffic going to and from a CP. If a site requires construction of roads or trails, make maximum use of natural concealment and existing terrain. The fewer new lines required, the better the CP blends, leaving natural features relatively unchanged.
- Never locate a CP at a road junction. Road junctions are high-priority targets for enemy forces and are easily detectable.
- Locate a CP in an existing civilian structure, if possible, which simplifies hiding military activity. However, choose a structure in an area where a sufficient number of buildings with similar EM signatures can mask its location and that provides a solution to control and reduce/mask traffic flow.

TELECOMMUNICATIONS PROCEDURES

7-8. By strictly complying with proper radio, telephone, and digital communications procedures, the opportunities for an enemy to detect friendly telecommunications activities are minimized. Consider the following:

- Place antennas in locations using natural supports when possible (trees for dipoles). As a rule of thumb, place antennas a minimum of one wavelength away from surrounding structures or other antennas.

Note. One wavelength is 40 meters (typically) for low frequencies and 1 meter for very high frequencies.

- Move antennas as often as possible within operational constraints.
- Use directional antennas when possible. If using nondirectional antennas, employ proper terrain-masking techniques to defeat the threat's radio direction-finding efforts.

- Use existing telephone lines as much as possible. Newly laid wire is a readily observable signature that can reveal a CP's location. Communications wire and cable should follow natural terrain lines and be concealed in the best way possible.

CAMOUFLAGE AND CONCEALMENT DISCIPLINE

7-9. Maintain camouflage and concealment discipline after occupying a site. Establish and use designated foot paths to, from, and within a CP's area. If a unit occupies a site for more than 24 hours, consider periodically rerouting foot paths to avoid detectable patterns. Conceal security and dismount points and other individual emplacements, and make paths to the CP inconspicuous. Enforce proper disposal procedures for trash and spoil. Rigidly enforce light and noise discipline. Enhance the realism of a decoy CP by making it appear operational. Allow camouflage and concealment discipline to be lax in the decoy CP, thus making it a more conspicuous target than the real CP.

LOGISTICS SITES

7-10. General supply items should be protected as time and materials permit. Supplies can be stored in the open, in tents, in MILVANs, or belowground (as required by the type of material). Both above- and belowground storage measures may be protected by various combinations of berms, revetments, and overhead cover. Additional measures to protect hazardous materials and hazardous wastes should be considered to prevent possible adverse health effects to personnel and to prevent environmental damage such as ground water contamination. (See FM 3-34.5/MCRP 4-11B and TC 3-34.489 for hazardous material/waste storage and protection requirements.) Ensure that firefighting equipment is available as needed to protect against fire and spills of hazardous materials.

7-11. The various activities involved in food, water, decontamination, clothing exchange, and bath points require protection for both customers and operating personnel. Equipment, such as power sources (generators), needs protection from indirect-fire fragmentation and direct fire. Operating personnel need both individual fighting positions and protective positions. Many of the shelter designs may be adapted for aboveground use in decontamination operations, clothing exchange, or bath points.

SUPPLY AND WATER POINTS

7-12. Supply and water points are relatively immobile and the object of an enemy's most sophisticated sensors. Using camouflage and concealment is an effective means to improve their survivability.

Camouflage and Concealment

7-13. Many camouflage and concealment methods associated with AAs and CPs also apply to supply and water points, but with additional requirements. Large amounts of equipment and supplies are quickly brought into tactical areas and delivered to supply points located as close to the forward line of own troops as possible. Supplies must be unloaded and concealed quickly, while supply points remain open and accessible for distribution. Under these conditions, multiple supply points are generally easier to camouflage than single, large ones. Decoy supply and water points can also confuse a threat's targeting efforts.

7-14. Take maximum advantage of natural cover and concealment. Configure logistics layouts to conform with the local ground pattern. Creativity can play a role in this effort. The following guidance enhances concealment of these operations:

- Avoid establishing regular (square or rectangular) perimeter shapes for an area.
- Select locations where concealed access and egress routes are already established and easily controlled.
- Use roads with existing overhead concealment if you need new access roads. Conceal access over short, open areas with overhead nets.
- Control movement into and out of the supply area.

- Mix and disperse supply point stocks to the maximum extent possible. This not only avoids a pattern of stockpile shapes but also avoids easy destruction of one entire commodity.
- Space stocks irregularly (in length and depth) to avoid recognizable patterns. Stack supplies as low as possible to avoid shadows. Dig supplies in if resources allow. In digging operations, disperse the spoil so as not to produce large piles of earth.
- Cover stocks with nets and other materials that blend with background patterns and signatures. Flattops (large, horizontal camouflage and concealment nets) are effective for concealing supply point activities when resources allow their construction and when supply points are not too large. Dunnage from supply points provides excellent material for expedient decoys.

Traffic Control

7-15. Ensure that vehicles cause minimal changes to the natural terrain as a result of movement into, within, and out of the area. Provide concealment and control of vehicles waiting to draw supplies. Rigidly practice and enforce camouflage and concealment discipline and OPSEC. Debris control could be a problem and requires constant attention. Military police can be used to support this effort by controlling traffic and enforcing discipline of movement. (See ATTP 3-39.10 for more information about military police support to traffic control.)

Water Points

7-16. Camouflage and concealment for water points includes the following additional considerations:

- **Spillage.** Water spillage can have positive and negative effects on a unit's camouflage and concealment posture. Standing pools of water reflect light that is visible to observers. Pools can also act as forward scatterers of radar waves, resulting in conspicuous black-hole returns on radar screens. Therefore, minimize water spillage and provide adequate drainage for runoff. On the other hand, dispersed water can be used to reduce the thermal signatures of large, horizontal surfaces. However, use this technique sparingly and in such a way that pools do not form.
- **Equipment.** Use adequate natural and artificial concealment for personnel, storage tanks, and specialized pumping and purification equipment. Conceal water-point equipment to eliminate shine from damp surfaces. Conceal shine by placing canvas covers on bladders, using camouflage nets, and placing foliage on and around bladders. This also distorts the normal shape of the bladders.
- **Scheduling.** Enhance camouflage and concealment discipline at water points by establishing and strictly enforcing a supply schedule for units. The lack of or violation of a supply schedule produces a concentration of waiting vehicles that is difficult to conceal.

AMMUNITION

7-17. Areas used to handle and store ammunition must be protected against hostile fire, accidents, and the elements. These areas include those adjacent to fighting positions, and storage areas in the field or on base camps. Several types of bunker designs, including buried MILVANs, aboveground MILVANs (with earth cover or revetments), concrete, and soil-filled containers are suitable to protect ammunition. Smaller quantities stored at fighting positions may be kept in pits or in positions within walls and revetments. Provisions must be made to integrate drainage and proper ventilation. Ensure that ammunition, fuzes, and ignition systems are stored separately as required by ammunition type. It is also essential to maintain firefighting equipment and to take appropriate measures to secure ammunition against theft. Whenever possible, store ammunition away from key infrastructure, CPs, fuel, and personnel housing areas. For additional information, see ATP 4-35.1.

FUEL SITES

7-18. POL products are a critical supply category, especially for mechanized and armored units conducting offensive tasks. Tanker trucks at the refueling points are protected by natural berms, deep-cut protective positions, or constructed berms. Overhead cover is impractical for short periods of occupancy, but maximum use is made of camouflage nets and natural terrain concealment. When it is expected that supply

vehicles will occupy particular locations for longer periods, overhead cover is essential to maximize the protection level.

7-19. Bulk fuel sites also require protection. Berms and revetments are emplaced around fuel bladders to provide limited protection against blast and fragmentation and to contain spills and fires. Pumping equipment and hoses should also be protected when possible against both enemy attack and accidents. Fire protection equipment is essential to mitigate damage caused by fire and hazardous materials. Drainage must be incorporated in the design to prevent water from collecting in the enclosed areas and protection must be included to prevent environmental damage.

MEDICAL TREATMENT FACILITIES

7-20. The amount of equipment emplaced at a medical treatment facility varies from mission to mission. Design and construction of shelters with adequate overhead cover is mandatory so that medical care and treatment is not interrupted by hostile action. Enemy activity may hinder prompt evacuation of patients from the medical company; thus, adequate shelter for both holding and treating patients becomes paramount. For planning purposes, shelters for protecting personnel on litters or folding cots and smaller shelters for surgery, X-ray, laboratory, dental, and triage functions are considered. The deliberate shelters are generally well suited to these activities. Protection for personnel organic to medical companies is provided by fighting positions and, when the situation permits, shelters are constructed for sleeping or other activities. Vehicle protective positions may be used to provide cover for ambulances and other vehicles.

7-21. Battalion aid stations normally operate from a vehicle situated behind natural terrain cover. As time and resources permit, this site is improved with overhead cover and berms allowing vehicle access and egress. Although the patient-holding capacity of the aid station is extremely limited, some permanent shelters are provided for patients held during periods when enemy activity interrupts evacuation.

AVIATION SITES

7-22. Airfield survivability considerations include protecting critical aircraft parking ramps, runways, and maintenance facilities. These measures include providing for berms and revetments, bunkers, and protective shelters for personnel, vehicles, aircraft, and equipment. Perimeter security features will emphasize standoff fences and barriers. In addition, the use of ECPs at airfield entrances is recommended. (See appendix A for further discussion of ECPs). Revetments and berms using a variety of materials will substantially increase aircraft survivability. The use of revetments to protect individual aircraft is extremely effective. When using revetments, it is important to ensure that proper distances are used between revetment walls to allow adequate space for aircraft operations (maintenance, fueling, arming) and repositioning of aircraft using a tug or other towing device. Distances between revetment walls must be increased significantly if aircraft are required to take-off or land inside the revetment area. (See FM 5-430-00-2/MCRP 3-17.7B for additional information about revetments for aviation sites.) Measures for facility hardening may also be implemented to protect critical airfield infrastructure.

7-23. Soil-filled container revetments are one of the most effective methods to protect aircraft while on the ground. Overhead cover is not practical for rotary wing aircraft since these aircraft must take off and land from protected positions. GTA 90-01-011 provides details and examples of soil-filled container revetments for various aircraft, including bills of material and the recommended equipment and personnel to construct the revetment.

7-24. Aviation sites are among the most important of all critical assets. Aviation sites are typically comprised of several parts that make up the whole, including tactical assembly areas (TAAs), aviation maintenance areas, forward operations bases, and FARPs. The positioning of these elements with respect to each other is dynamic and often depends on the existing tactical situation. In the following discussion, an aviation site will be assumed to contain a TAA, an aviation maintenance area, and a FARP collocated in the same area. While these elements are not always collocated, the camouflage and concealment techniques for individual elements will not greatly differ based on positioning. Untreated aviation sites are detectable in most threat sensor wavelengths. Aviation sites may include the following:

- **TAA.** A TAA is typically a parking area for helicopters. Helicopters are highly conspicuous targets because of their awkward shape, distinctive thermal signatures, and large radar cross section. An enemy expends a lot of time and energy attempting to locate TAAs. Once it finds them, the enemy aggressively directs offensive actions against them.
- **Aviation maintenance area.** The most conspicuous features of an aviation maintenance area are the large transportable maintenance shelters. These shelters are highly visible and indicate the presence of helicopters to an enemy. Aviation maintenance areas occupy large areas to allow for ground handling of aircraft. Traffic patterns around aviation maintenance areas are also strong visual cues to the enemy. Maintenance assets, including aviation shop sets, have characteristically distinct multispectral cues.
- **FARP.** A FARP provides POL and ammunition support to aviation sites and other tactical units. A FARP consists of fuel bladders, trucks, fueling apparatus, and bulk ammunition. Due to safety requirements, FARP elements are dispersed as much as possible within terrain and operational constraints. Each element is detectable with multispectral radar. In a FARP—
  - Fuel bladders contain petroleum liquids whose thermal mass is a strong infrared cue relative to the background. Bladders are often bermed, which means that visible earth scarring is necessary to construct the berm.
  - Large heavy expanded mobility tactical trucks are conspicuous in all wavelengths.
  - Fueling areas are generally arranged in such a way that the fueling apparatus (hoses, pumps) are arranged linearly in an open area for safe and easy access. The linear deployment of these hoses is a strong visual cue, and their dark color usually contrasts with the background. The dark hoses experience solar loading, and the POL liquids within the hoses can provide a thermal cue.
- **Equipment.** Palletized ammunition and support equipment accompany aviation sites. Such equipment is often stacked in regular, detectable patterns.
- **Aircraft.** Aircraft create large dust plumes when deployed to unpaved areas. Such plumes are distinct visual cues and indicate the presence of rotary-wing aircraft to an enemy. Other considerations for aircraft camouflage and concealment include the following:
  - **Parked aircraft.** Camouflage nets, berms, stacked equipment, and revetments can effectively conceal parked aircraft. Vertical screens constructed from camouflage nets help conceal parked aircraft, particularly against ground-based threats. However, camouflage and concealment techniques for rapid-response aircraft must not impair operational requirements, meaning that obtrusive, permanent camouflage and concealment techniques are generally not an option. Also, foreign object damage is a critical concern for all aviation assets. Camouflage and concealment for parked aircraft depends on the expected ground time between flights. The commanding officer must approve all aircraft camouflage and concealment techniques before implementation.
  - **Aircraft refueling.** Aircraft refueling positions, particularly fuel hoses, should be dispersed and arrayed in a nonlinear configuration. The hoses can be concealed at periodic locations with cut vegetation or a light earth/sod covering to reduce visual and thermal signatures.
- **Defensive positions.** Constructing defensive positions can create detectable areas of scarred earth.
- **Camouflage and concealment.** Aviation sites are extremely valuable targets; therefore, try to prevent their initial detection by an enemy.
- **Vehicles.** Large vehicles can be effectively concealed with camouflage nets. Also, properly placing these vehicles to use terrain features and indigenous vegetation increases their survivability. Expedient vehicle decoys provide an enemy with alternate targets, and proper camouflage and concealment discipline is essential.
- **Dunnage.** Quickly conceal all dunnage (packing materials) to minimize the evidence of aviation sites.
- **Dust.** To avoid dust, park aircraft in grassy areas or where the earth is hard-packed. If such areas are unavailable, disperse water on the area to minimize dust plumes. However, water-soaked earth can also be an infrared detection cue so use this option sparingly and, if possible, at night.

Several chemical dust palliatives are available that provide excellent dust control for aviation areas.

- **Construction.** When constructing defensive positions, minimize disturbances to the surrounding area. Cover scarred earth with cut vegetation, camouflage nets, or toned-down agents.

Note. See FM 3-34.400/MCWP 3-17.7 and FM 5-430-00-2/Air Force Joint Pamphlet 32-8013, Volume II/MCRP 3-17.7B for additional information on engineering support to aviation sites.

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Chapter 8
Special Environments

Survivability operations and associated camouflage and concealment may be conducted in jungles, mountainous areas, deserts, cold regions, and urban areas. Each environment presents its own challenges to planning, designing, and constructing fighting and protective positions—requiring specialized knowledge, skills, techniques, and equipment. The fundamentals of providing cover, camouflage, and concealment do not change between environments. However, the guidelines for their application change. This chapter describes several special environments; their impacts on survivability efforts; thoughtful, creative, and unique camouflage and concealment techniques; and some special considerations for operating within them.

JUNGLES

8-1. Jungles are humid, tropical areas with a dense growth of trees and vegetation. Visibility is typically less than 100 feet, and areas are sparsely populated. Because mounted infantry and armor operations are limited in jungle areas, individual and crew-served weapons fighting position construction and use receive additional emphasis. While jungle vegetation provides excellent concealment from air and ground observation, fields of fire are difficult to establish. Vegetation does not provide adequate cover from small-caliber direct fire and artillery indirect-fire fragments. Adequate cover is available by using the natural ravines and gullies produced by erosion from the area's high rainfall amounts. FM 90-5 provides more information on fighting positions and camouflage and concealment in jungle environments.

CONSIDERATIONS FOR COVER

8-2. The few natural or locally-procurable materials which are available in jungle areas are usually limited to camouflage use, although certain trees may be suitable for survivability construction. Survivability construction materials are transported to these areas and are required to be weather and rot resistant. When shelters are constructed in jungles, primary consideration is given to drainage provisions. Because of high amounts of rainfall and poor soil drainage, positions are built to allow for good, natural drainage routes. All survivability construction, including that used to protect storage areas, CPs, and infrastructure, must include planning for drainage. This technique not only prevents flooded positions but also prevents the accumulation of contaminants. Other considerations are high water tables, dense undergrowth, and tree roots, which often require aboveground-level protective construction.

8-3. Construction of individual and vehicle protective and fighting positions will be limited by the water table and high rainfall amounts. Vehicle positions will generally be constructed above ground, using earth berms and sandbag or soil-filled container construction techniques. Where groundwater is high, or where there is a low-pressure resistance soil, a swamp bed (see FM 3-05.70 and MCRP 3-02F) can be used as a fighting position platform. This platform provides a floating base or floor where wet or low-pressure resistance soil precludes standing or sitting.

CONSIDERATIONS FOR CAMOUFLAGE AND CONCEALMENT

8-4. The color of jungle terrain primarily consists of greens and browns, but due to shadows and growth, black is also a key color. Density of vegetation and time of the day will cause variances in colors. While no set color or combination of colors matches all jungles, generalities are more easily used than in deserts. Patches of uniform color in the jungle will be significantly less than those in deserts.

Topography

8-5. Jungle terrain has many features, although at a distance many of the features may not stand out. Remember that the terrain underneath the vegetation is not completely flat and may include significant bodies of water or marshland.

Shadows

8-6. The jungle typically provides for deep shadows, and triple canopy may nearly exclude the penetration of sunlight. Draping of camouflage nets will still be necessary on the edges of the jungle or at breaks in the foliage. Because of the natural vegetation, smaller sections of camouflage nets will be of greater value than in more open terrain.

Placement

8-7. Proper placement and shadow disruption remain effective techniques. Optimize the natural cover and concealment to reduce shadows and silhouettes and to take advantage of terrain masking. Although virtually unimportant in portions of the jungle, moving assets as the sun changes position may still be required to keep in the shadows.

Terrain Mottling

8-8. While not as likely, terrain mottling may be an effective technique on the edges of the jungle, or in clearing areas within larger jungle areas. (See paragraph 6-66 for information about terrain mottling.)

Movement Discipline

8-9. Movement discipline remains important in jungle terrain. Vegetation moved near its base may still sway at its tip and give away your location. The density of foliage may make it necessary to cut your way through portions. Fresh cuts may become apparent to observers. Straight-line movement may be virtually impossible in some portions of a jungle. Chopping or cutting of vegetation will produce audible signature, especially if the cutting devices are mechanical. The dispersion of birds and other jungle creatures may also provide a visible and audible signature of movement in the jungle.

Noise and Light Discipline

8-10. Noise and light discipline remains important in the jungle although many sounds will be muted by the vegetation. Cutting noises and the movement of displaced birds and other creatures will provide audible and visual alerts to movement.

MOUNTAINOUS AREAS

8-11. Characteristics of mountain ranges include rugged, poorly trafficable terrain, steep slopes, and altitudes greater than 1,600 feet. Irregular mountain terrain provides numerous places for cover and concealment. Because of rocky ground, it is difficult and often impossible to dig belowground positions; therefore, boulders and loose rocks are used in aboveground construction. Irregular fields of fire and dead spaces are considered when designing and locating fighting positions in mountainous areas. FM 3-97.6 and TC 3-97.61 provide additional information on fighting positions and camouflage and concealment in mountainous areas.

CONSIDERATIONS FOR COVER

8-12. Reverse-slope positions are rarely used in mountainous terrain but they do have special applications; crest and near-crest positions on high ground are much more common. Direct-fire weapon positions in mountainous areas are usually poorly concealed by large fields of fire. Indirect-fire weapon positions are better protected from both direct and indirect fire when located behind steep slopes and ridges.

8-13. Another important design consideration in mountain terrain is the requirement for substantial overhead cover. The adverse effects of artillery bursts above a protective position are greatly enhanced by rock and gravel displacement or avalanche. Construction materials used for both structural and shielding components are most often indigenous rocks, boulders, and rocky soil. Often, rock formations are used as structural wall components without modification. Conventional tools are inadequate for preparing individual and crew-served weapons fighting positions in rocky terrain. Engineers assist with light equipment and tools (such as pneumatic jackhammers) delivered to mountain areas by helicopter. Explosives and demolitions can be used for positions requiring rock and boulder removal.

8-14. In areas with rocky soil or gravel, wire cages or gabions are used as building blocks in protective walls, structural walls, and fighting positions. Gabions are constructed of lumber, plywood, wire fence, or any suitable material that forms a stackable container for soil or gravel. The two-person mountain shelter is basically a hole 7 feet long, 3 ½ feet wide, and 3 ½ feet deep. The hole is covered with 6- to 8-inch diameter logs with evergreen branches, a shelter half, or local material such as topsoil, leaves, snow, and twigs placed on top. The floor is usually covered with evergreen twigs, a shelter half, or other expedient material. Entrances can be provided at both ends or a fire pit is sometimes dug at one end for a small fire or stove. A low earth berm is built around the position to provide more height for the occupants.

Considerations for Camouflage and Concealment

8-15. The color of mountainous terrain varies across the spectrum of color, depending on the minerals in the soil, whether tree or other vegetation covered, and the time of the day. No color or combination of colors matches all mountainous terrain.

Topography

8-16. Mountainous terrain is extremely varied to include plateaus that may include similarities to desert terrain. The likelihood that selected portions will also be snow covered is also high.

Shadows

8-17. The closer a target is to the ground, the smaller its shadow; and a small shadow is easier to conceal from aerial observation. The proper draping of camouflage nets will alter or disrupt the regular, sharp-edged shadows of military targets and allow target shadows to appear more like natural shadows. When supplemented by artificial materials, natural shadows cast by folds of the ground can be used for camouflage and concealment purposes. The best solution to the shadow problem in mountainous terrain is to blend in with the natural shadows and use overhead concealment or cover for terrain masking. Remember that shadows may shift dramatically during the daylight hours. Park vehicles in a way that minimizes their broadside exposure to the sun.

Placement

8-18. Proper placement and shadow disruption remain effective techniques. Place assets in gullies, folds, ravines, overhangs, and other natural cover and concealment to reduce their shadows and silhouettes and to take advantage of terrain masking. Less dispersion is typically necessary than in desert terrain or other relatively flat areas. Move assets as the sun changes position to keep equipment in shadows.

Terrain Mottling

8-19. The scarring techniques associated with terrain mottling may work in selected situations but is less likely to be useful than perhaps in desert areas. (See paragraph 6-66 for information about terrain mottling.)

Movement Discipline

8-20. Movement discipline is especially important in mountainous terrain. The irregular surfaces will make movement less fluid, potentially loosening stone and other materials that will fall to lower levels producing an audible and visual signature. Dust and diesel plumes may also be highlighted against the backdrop

terrain. Shine or reflection may also be an issue since it can be seen for an extended distance. Shade optical devices (binoculars, gun sights) when using them.

Noise and Light Discipline

8-21. Noise and light discipline is particularly important in mountainous terrain, since sound and light can be detected at greater distance and sounds caused by falling objects may last for a longer time. The techniques for reducing these signatures remain the same as for other environments. Starting all vehicle and equipment engines simultaneously is a technique that can be used to confuse enemy acoustical surveillance efforts.

DESERTS

8-22. Deserts are extensive, arid, and treeless; suffer from a severe lack of rainfall; and possess extreme daily temperature fluctuations. The terrain is sandy with boulder-strewn areas, mountains, dunes, deeply-eroded valleys, areas of rock and shale, and salt marshes. Effective natural barriers are found in steep slope rock formations. Wadis and other dried up drainage features are used extensively for protective position placement. FM 90-3/MCWP 3-35.6 provides additional information on fighting positions and camouflage and concealment in deserts.

CONSIDERATIONS FOR COVER

8-23. Designers of fighting and protective positions in desert areas must consider the lack of available natural cover and concealment. The only minimal cover available is through the use of terrain masking; therefore, positions are often completed above ground. Mountain and plateau deserts have rocky soil or "surface chalk" soil which makes digging difficult. In these areas, rocks and boulders are used for cover. Most often, berms used in desert fighting or protective positions are undesirable because of probable enemy detection in the flat desert terrain. Deep-cut positions are also difficult to construct in soft sandy areas because of wall instability during excavations. Revetments are almost always required, unless excavations are very wide and have gently sloping sides of 45 degrees or less. Designing overhead cover is additionally important because nuclear explosions have increased fallout due to easily displaced sandy soil.

8-24. Indigenous materials are usually used in desert position construction. However, prefabricated structures and revetments for excavations, if available, are ideal. Although excavation may be relatively easy, depending on the soil type, additional care must be taken to prevent sandy soil from caving into fighting positions and survivability construction must include adequate surface area and compaction of the bearing surface for posts and beams. In addition, the open terrain, persistent winds, and the type of soil may require frequent maintenance of earth berms to correct wind and water erosion issues. Metal culvert revetments are quickly emplaced in easily excavated sand. Sandbags, sand-filled ammunition boxes, and soil-filled containers are also used for containing backsliding soil. Therefore, camouflage and concealment, as well as light and noise discipline, are important considerations during position construction. Target acquisition and observation are relatively easy in desert terrain.

CAUTION

Unless it is constructed properly, any fighting position can easily collapse and crush or bury the Soldiers/Marines within. The instability of sand soils makes positions constructed in such soil especially prone to this hazard. It is critical that positions are built according to established guidelines outlined in this ATP, FM 5-34/MCRP 3-17A, and GTA 05-08-001.

CONSIDERATIONS FOR CAMOUFLAGE AND CONCEALMENT

8-25. The color of desert terrain varies from pink to blue, depending on the minerals in the soil and the time of the day. No color or combination of colors matches all deserts. Patches of uniform color in the desert are usually ten times larger than those in wooded areas. These conditions have led to the development of a neutral, monotone tan as the best desert camouflage paint color.

Topography

8-26. Although desert terrain may appear featureless, it is not completely flat. In some ways, desert terrain resembles unplowed fields; barren, rocky areas; grasslands; and steppes.

Shadows

8-27. The closer a target is to the ground, the smaller its shadow; and a small shadow is easier to conceal from aerial observation. The proper draping of camouflage nets will alter or disrupt the regular, sharp-edged shadows of military targets and allow target shadows to appear more like natural shadows. When supplemented by artificial materials, natural shadows cast by folds of the ground can be used for camouflage and concealment purposes. The best solution to the shadow problem in desert terrain is to dig in and use overhead concealment or cover. Otherwise, park vehicles in a way that minimizes their broadside exposure to the sun.

Placement

8-28. Proper placement and shadow disruption remain effective techniques. Place assets in gullies, washes, wadis, and ravines to reduce their shadows and silhouettes and to take advantage of terrain masking. More dispersion is necessary in desert terrain than in wooded areas. Move assets as the sun changes position to keep equipment in shadows.

Terrain Mottling

8-29. Use terrain mottling when the ground offers little opportunity for concealment. (See paragraph 6-66 for information about terrain mottling.)

Movement Discipline

8-30. Movement discipline is especially important in the desert. Desert terrain is uniform and fragile, making it easily disturbed by vehicle tracks. Vehicle movement also produces dust and diesel plumes that are easily detectable in the desert. When movement is necessary, move along the shortest route and on the hardest ground. Shine is a particularly acute desert problem due to the long, uninterrupted hours of sunlight. To deal with this problem, remove all reflective surfaces or cover them with burlap. Use matte camouflage paint or expedient paints (see table 6-2, page 6-15) to dull the gloss of a vehicle’s finish. Shade optical devices (binoculars, gun sights) when using them.

Noise and Light Discipline

8-31. Noise and light discipline is particularly important in desert terrain since sound and light can be detected at greater distances on clear desert nights. The techniques for reducing these signatures remain the same as for other environments. Be aware that thermal sensors, while not as effective during the day, have an ideal operating environment during cold desert nights. Starting all vehicle and equipment engines simultaneously is a technique that can be used to confuse enemy acoustical surveillance efforts.

COLD REGIONS

8-32. Cold regions of the world are characterized by deep snow, permafrost, seasonally frozen ground, frozen lakes and rivers, glaciers, and long periods of extremely cold temperatures. ATTP 3-97.11/MCRP 3-35.1D provides detailed information on the considerations associated with arctic and cold region operations.

CONSIDERATIONS FOR COVER

8-33. Digging in frozen or semifrozen ground is difficult with equipment, and virtually impossible for Soldiers/Marines using only standard entrenching tools. When possible, positions are designed to take advantage of belowground cover. Positions are dug as deep as possible, then built up. Fighting and protective position construction in snow or frozen ground takes up to twice as long as positions in unfrozen ground. Also, positions used in cold regions are affected by wind and the possibility of thaw during warming periods. An unexpected thaw causes a severe drop in the soil strength which creates mud and drainage problems. Positions near bodies of water, such as lakes or rivers, are carefully located to prevent flooding damage during the spring melt season. Wind protection greatly decreases the effects of cold on Soldiers/Marines and their equipment. The following areas offer good wind protection:

- Densely wooded areas.
- Groups of vegetation; small blocks of trees or shrubs.
- The lee side of terrain elevations. (The protected zone extends horizontally up to three times the height of the terrain elevation.)
- Terrain depressions.

8-34. The three basic construction materials available in cold region terrain are snow, ice, and frozen soil. Positions are more effective when constructed with these three materials in conjunction with timber, stone, or other locally-available materials.

CONSIDERATIONS FOR CAMOUFLAGE AND CONCEALMENT

Snow-Covered Areas

8-35. When the main background is white, apply white paint or whitewash over the permanent camouflage paint pattern. The amount of painting should be based on the percentage of snow coverage on the ground as follows:

- If the snow covers less than 15 percent of the background, do not change the camouflage paint pattern.
- If the snow cover is 15 to 85 percent, substitute white for green in the camouflage paint pattern.
- If the snow cover is more than 85 percent, paint the vehicles and equipment completely white.

Placement

8-36. A blanket of snow often eliminates much of the ground pattern, causing natural textures and colors to disappear. Blending under these conditions is difficult. However, snow-covered terrain is rarely completely white so use the dark features of the landscape. Place equipment in roadways, in streambeds, under trees, under bushes, in shadows, and in ground folds. Standard uniforms and personal equipment contrast with the snow background, so use camouflage and concealment to reduce these easily recognized signatures.

Movement Discipline

8-37. Concealing tracks is a major problem in snow-covered environments. Movement should follow wind-swept drift lines, which cast shadows, as much as possible. Vehicle drivers should avoid sharp turns and follow existing track marks. Wipe out short lengths of track marks by trampling them with snowshoes or by brushing them out.

Thermal Signatures

8-38. Snow-covered environments provide excellent conditions for a threat’s thermal and ultraviolet sensors. Terrain masking is the best solution to counter both types of sensors. Use arctic LCSS and winter camouflage paint to provide ultraviolet blending, and use smoke to create near-whiteout conditions.

SNOW

8-39. Dry snow is less suitable for expedient construction than wet snow because it does not pack as well. Snow piled at road edges after clearing equipment has passed becomes denser and begins to harden within hours after disturbance, even at very low temperatures. Snow compacted artificially, by the wind, and after a brief thaw is even more suitable for expedient shelters and protective structures. A uniform snow cover with a minimum thickness of 10 inches is sufficient for shelter from the weather and for revetment construction. Blocks of uniform size, typically 8 by 12 by 16 inches, depending upon degree of hardness and density, are cut from the snow pack with shovels, long knives (machetes), or carpenter's saws. The best practices for constructing cold-weather shelters are those adopted from natives of polar regions.

8-40. The systematic overlapping block-over-seam method ensures stable construction. "Caulking" seams with loose snow ensures snug, draft-free structures and increases their longevity. Snow positions are built during either freezing or thawing if the thaw is not so long or intense that significant snow melt conditions occur. Mild thaw of temperatures 1 or 2 degrees above freezing are more favorable than below-freezing temperatures because snow conglomerates readily and assumes any shape without disintegration. Below-freezing temperatures are also necessary for snow construction to achieve solid freezing and strength. If water is available at low temperatures, expedient protective structures are built by wetting down and shaping snow, with shovels, into the desired forms. (For information on snow shelters and other cold region shelters, see FM 3-05.70, MCRP 3-02F, and TC 21-3.)

ICE

8-41. The initial projectile-stopping capability of ice is better than snow or frozen soil; however, under sustained fire, ice rapidly cracks and collapses. Ice structures are built in the following three ways:

- **Layer-by-layer freezing by water.** This method produces the strongest ice but, compared to the other two methods, is more time consuming. Protective surfaces are formed by spraying water in a fine mist on a structure or fabric. The most favorable temperature for this method is -10 to -15 degrees Celsius with a moderate wind. About 2 to 3 inches of ice are formed per day between these temperatures (1/5-inch of ice per degree below zero).
- **Freezing ice fragments into layers by adding water.** This method is very effective and the most frequently used for building ice structures. The ice fragments are about 1 inch thick and prepared on nearby plots or on the nearest river or water reservoir. The fragments are packed as densely as possible into a layer 8 to 12 inches thick. Water is then sprayed over the layers of ice fragments. Crushing the ice fragments weakens the ice construction. If the weather is favorable (-10 to -15 degrees Celsius with wind), a 16- to 24-inch thick ice layer is usually frozen in a day.
- **Laying ice blocks.** This method is the quickest, but requires assets to transport the blocks from the nearest river or water reservoir to the site. Ice blocks, laid and overlapped like bricks, are of equal thickness and uniform size. To achieve good layer adhesion, the preceding layer is lightly sprayed with water before placing a new layer. Each new layer of blocks freezes onto the preceding layer before additional layers are placed.

FROZEN SOIL

8-42. While ice has a better initial projectile stopping capability, frozen soil is three to five times stronger than ice, and increases in strength with lower temperatures. Frozen soil has much better resistance to impact and explosion than to steadily-acting loads—an especially valuable feature for position construction purposes. Construction using frozen soil is performed as follows:

- Prepare blocks of frozen soil from a mixture of water and aggregate (icecrete).
- Lay the prepared blocks of frozen soil.
- Freeze the blocks of frozen soil together in layers.

8-43. Unfrozen soil from beneath the frozen layer is sometimes used to construct a position quickly before the soil freezes. Material made of gravel-sand-silt aggregate mixed with water to a consistency similar to Portland cement concrete is also suitable for constructing positions. After freezing, the material has the

properties of concrete. The construction methods used are analogous to those using ice. Fighting and protective positions in arctic areas are constructed both belowground and aboveground.

Belowground Positions

8-44. When the frost layer is one foot or less, fighting positions are usually constructed belowground. Snow packed 8 to 9 feet provides protection from sustained direct fire from small-caliber weapons up to and including the 14.5-millimeter machine gun. When possible, unfrozen excavated soil is used to form berms about 2 feet thick, and snow is placed on the soil for camouflage and extra protection. For added frontal protection, the interior snow is reinforced with a log revetment at least 3 inches in diameter. The outer surface is reinforced with small branches to initiate bullet tumble upon impact. Bullets slow down very rapidly in snow after they begin to tumble. The wall of logs directly in front of the position safely absorbs the slowed tumbling bullet.

8-45. Overhead cover is constructed with 3 feet of packed snow placed atop a layer of 6-inch diameter logs. This protection is adequate to stop indirect-fire fragmentation. A layer of small, 2-inch diameter logs is placed atop the packed snow to detonate quick-fuzed shells before they become imbedded in the snow. Figure 8-1 shows belowground fighting positions in snow.

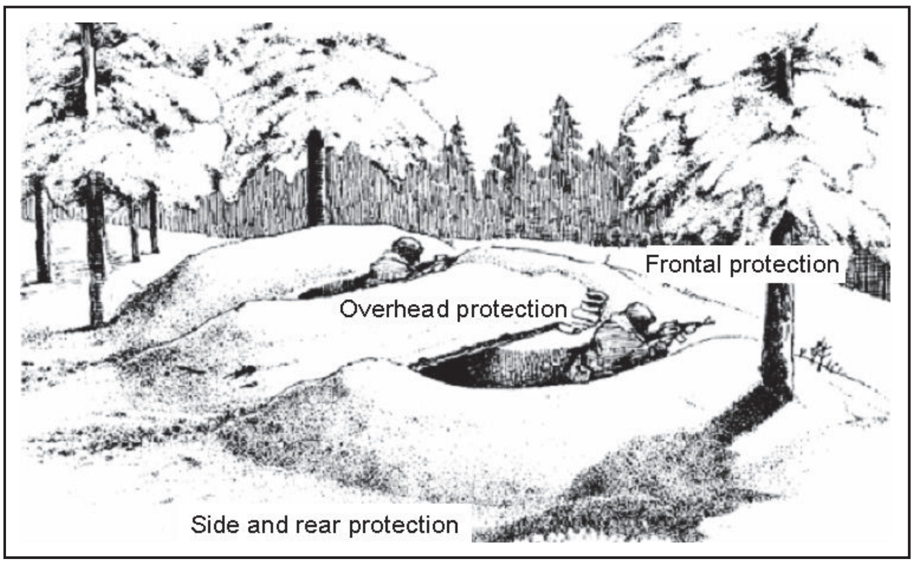

Figure 8-1. Belowground fighting position in snow

Aboveground Positions

8-46. If the soil is frozen to a significant depth, Soldiers/Marines equipped with only standard entrenching tools and axes will have difficulty digging fighting positions. Under these conditions (below the tree line), snow and wood are often the only natural materials available to construct fighting positions. The fighting position is dug at least 20 inches deep, up to chest height, depending on snow conditions. Ideally, sandbags are used to revet the interior walls for added protection and to prevent cave-ins. If sandbags are not available, a lattice framework is constructed using small branches or, if time permits, a wall of 3-inch logs is built. Overhead cover, frontal protection, and side and rear berms are built employing the same techniques described in chapter 4.

8-47. It is approximately ten times faster to build aboveground snow positions than to dig in frozen ground to obtain the same degree of protection. Fighting and protective positions constructed in cold regions are excavated with combined methods using handtools, excavation equipment, or explosives. Heavy equipment use is limited by traction and maneuverability. Explosives are an expedient method, but require larger quantities than used in normal soil. (See FM 3-34.214/MCRP 3-17.7L for information on using explosives to excavate fighting positions and considerations for their use in ice and permafrost.)

SPECIAL COLD-REGION POSITIONS

8-48. A platform of plywood or timber is constructed to the rear of the frontal protection to provide a solid base from which to employ the guns. Overhead cover is usually offset from the firing position because of the difficulty of digging both the firing and protective positions together in the snow. The protective position should have at least 3 feet of packed snow as cover. The fighting position should have snow packed 8 to 9 feet thick for frontal, and at least 2 feet thick for side protection (as shown in figure 8-2). Sandbags are used to revet the interior walls for added protection and to prevent cave-ins. However, packed snow, rocks, 4-inch diameter logs, or ammunition cans filled with snow are sometimes used to complete the frontal and overhead protection, as well as side and rear berms. Figure 8-2 shows dismounted tube-launched optically-tracked wire-guided (TOW), Javelin, and machine gun positions in snow.

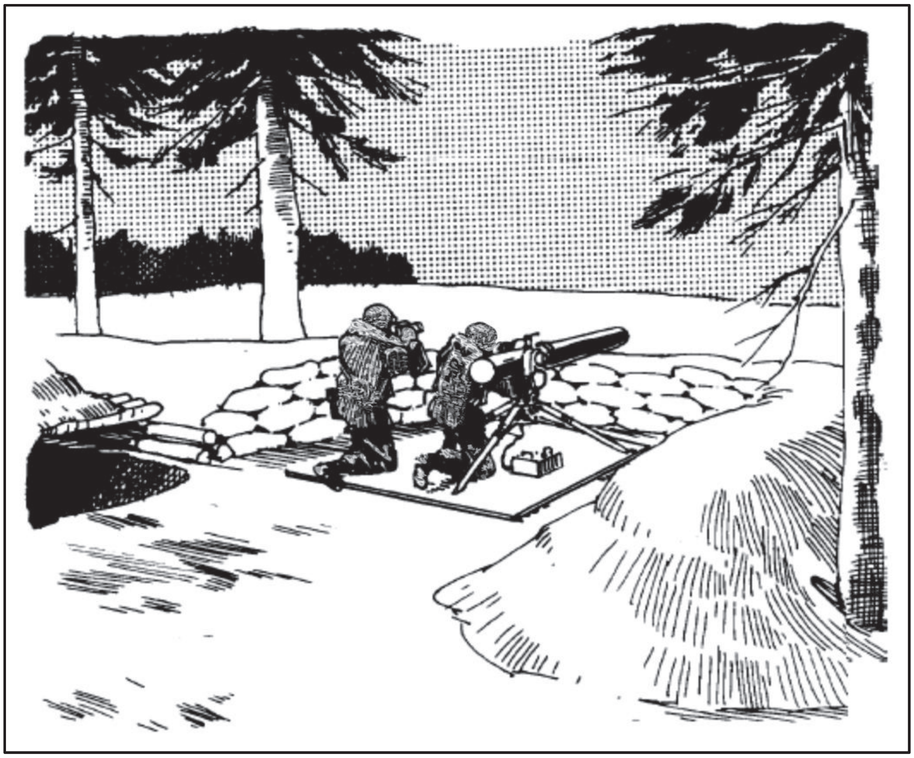

Figure 8-2. Dismounted antitank and machine gun positions in snow

8-49. Positions for individuals are constructed by placing packed snow on either side of a tree and extending the snow berm 8 to 9 feet to the front, as shown in figure 8-3, page 8-10. The side and rear berms are constructed of a continuous snow mound, a minimum of 2 feet wide, and high enough to protect the Soldier's/Marine's head.

Figure 8-3. Individual fighting position in snow

8-50. In deep snow, revetments for trenches and weapon positions are required unless the snow is well packed and frozen. In snow too shallow to permit the required depth excavation, snow walls are usually constructed. The walls are made of compacted snow, revetted, and at least 6 1/2 feet thick. Figure 8-4 shows a snow trench with a wood revetment. Table 8-1 contains snow wall construction requirements.

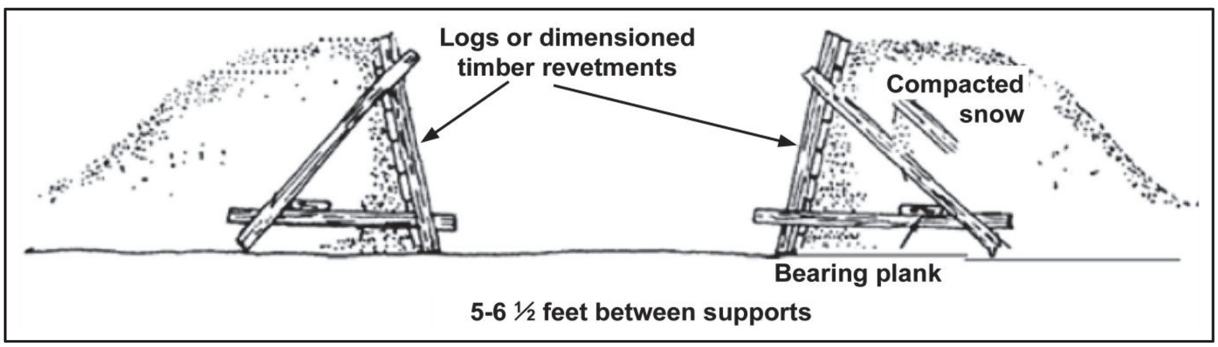

Figure 8-4. Snow trench with wood revetment

Table 8-1. Snow wall construction for protection from grenades, small-caliber fire, and high-explosive antitank projectiles

Snow Density (pounds per cubic foot)	*Projectiles*	*Muzzle Velocity (feet per second)*	*Penetration, feet*	*Required Minimum Thickness (feet)*
18.0 -25.0	Grenade fragmentation (HE)		2.0	3.0
11.2 -13.0	5.56 mm	3,250	3.8	4.4
17.4 -23.7	5.56 mm	3,250	2.3	2.6
11.2 -13.1	7.62 mm	2,750	13.0	15.0
17.4 -23.7	7.62 mm	2,750	5.2	6.0
25.5 -28.7	7.62 mm	2,750	5.0	5.8
19.9 -24.9	12.7 mm	2,910	6.4	7.4
28.1 -31.2	70-mm HEAT	900	14.0	17.5
31.2 -34.9	70-mm HEAT	900	8.7 -10.0	13.0
27.5 -34.9	90-mm HEAT	700	9.5 -11.2	14.5

Note.

1. These materials degrade under sustained fire. Penetrations given for 12.7 millimeters or smaller are for sustained fire (30 continuous firings into a 1- by 1-foot area).
2. Penetration characteristics of former Warsaw Pact ammunitions do not differ significantly from U.S. counterparts.
3. Figure given for HEAT weapons is for former Soviet PRG-7 (70 millimeter) and U.S. M67 (90 millimeter) fired into machine-packed snow.
4. High-explosive grenades produce small, high-velocity fragments which stop in about 2 feet of packed snow. Effective protection from direct fire is independent of delivery method, including newer machine guns like the former Soviet AGS-17 (30 millimeter) or U.S. MK 19/M75 (40 millimeter). Only armor penetrating rounds are effective.

Legend:

HE – high explosive   HEAT – high explosive antitank   mm – millimeter   U.S. – United States

URBAN AREAS

8-51. Survivability of forces operating in urban areas depends on the leader's ability to locate adequate fighting and protective positions from the many apparent covered and concealed areas available. Fighting and protective positions range from hasty positions formed from piles of rubble, to deliberate positions located inside urban structures. Urban structures are the most advantageous locations for individual fighting positions. FM 3-06 and ATTP 3-06.11 contain detailed and thorough information on fighting positions and camouflage and concealment in urban terrain. This section provides additional considerations not addressed in those manuals.

8-52. ATTP 3-06.11 describes urban environments as including urban airspace, supersurface (tops of buildings), surface (ground, street, and water level), and subsurface (underwater and subterranean) areas, and it emphasizes the importance of considering both exterior and interior space. It describes buildings using five interrelated aspects that characterize all buildings—function, size, height, materials, and construction methods—and two additional aspects (exterior openings and floor plans) that determine the interior layout of a building.

8-53. Some multistory buildings are vulnerable to what is known as progressive collapse. Progressive collapse is where a building component that supports other components fails, leading to the supported components failing as well, potentially resulting in collapse of large portions of buildings as in a house of cards. Because of the load-bearing nature of exterior walls in buildings with stacked walls, such collapses are more common in these buildings. Consequently, where there are framed buildings available to be used for shelter or protection, consider using them rather than buildings with stacked walls. (See ATTP 3-06.11 for more information about stacked walls.)

URBAN STRUCTURES

8-54. Leaders use the characteristics of buildings (listed in paragraph 8-52 and described in ATTP 3-06.11) to evaluate them for protective soundness. The evaluation is based on troop protection available and weapon position employment requirements for cover, concealment, and routes of escape. Table 8-2 summarizes building characteristics fulfilling survivability requirements for troop protection.

Table 8-2. Survivability requirements for troops in urban buildings

Requirements	*Building Characteristics*
Cover	1. Proportion of walls to windows. 2. Wall composition and thickness. 3. Interior wall and partition composition and thickness. 4. Stair and elevator modules.
Concealment	1. Proportion of walls to windows. 2. Venting pattern. 3. Floor plan (horizontal and vertical). 4. Stair and elevator modules (framed high-rise buildings).
Escape	1. Floor plan (horizontal and vertical). 2. Stair and elevator modules.

Cover

8-55. The extent of building cover depends on the proportion of walls to windows. It is necessary to know the proportion of nonwindowed wall space which might serve as protection. Buildings with stacked walls, with their high proportion of walls to windows, afford more substantial cover than framed buildings having both a lower proportion of wall to window space and (usually) light-clad walls.

8-56. The composition and thickness of both exterior and interior walls also have a significant bearing on cover assessment. Buildings with stacked walls typically have strong weight-bearing walls that provide more cover than the typically light-clad walls of framed buildings. However, interior walls of the older, heavy-clad, framed buildings are stronger than those of the new, light-clad, framed buildings. Cover within these light-clad, framed buildings is very slight except in and behind their stair and elevator modules which are usually constructed of reinforced concrete. Familiarity with the location, dimension, and form of these modules is vital when assessing cover possibilities.

Concealment

8-57. Concealment considerations involve some of the same elements of building construction, but knowledge of the venting (window) pattern and floor plan is added.

8-58. These patterns vary with the type of building construction and function. Older, heavy-clad, framed buildings (such as office buildings) frequently have as full a venting pattern as possible, while hotels have only one window per room. In the newer, light-clad, framed buildings, windows are sometimes used as a nonload bearing curtain wall. If the windows are all broken, no concealment possibilities exist. Another aspect of concealment—undetected movement within the building—depends on a knowledge of the floor plan and the traffic pattern within the building on each floor and from floor to floor.

Escape

8-59. In planning for escape routes, the floor plan, traffic patterns, and the relationships between building exits are considered. Possibilities range from small buildings with front street exits (posing unacceptable risks), to high-rise structures having exits on several floors, above and below ground level, and connecting with other buildings as well.

Fighting Positions

8-60. Building characteristics fulfilling survivability requirements for fighting positions for individuals, machine guns, and AT and antiaircraft weapons are summarized in table 8-3.

Table 8-3. Survivability requirements for fighting positions in urban buildings

Requirements	***Building Characteristics***
Individual Positions	1. Wall compositions and thickness of upper floors. 2. Roof composition and thickness. 3. Floor and ceiling composition and thickness.
Machine Gun Positions	1. Wall composition and thickness. 2. Local terrain.
Antitank Weapon Positions	1. Wall composition and thickness. 2. Room dimensions and volume. 3. Function-related interior furnishings, and so forth. 4. Fields of fire (relative position of building). 5. Arming distance. 6. Line of sight. 7. Clear area and volume sufficient for weapon's backblast and overpressure.
Antiaircraft Weapon Positions	1. Roof composition and thickness. 2. Floor plan (horizontal and vertical). 3. Line of sight.

Individual Fighting Positions

8-61. An upper floor area of a multistoried building generally provides sufficient fields of fire, although corner windows can usually encompass more area. Protection from the possibility of return fire from the streets requires that Soldiers/Marines know the composition and thickness of the building's outer wall. Load-bearing walls generally offer more protection than the typically light-clad walls of framed buildings. However, the relatively thin walls of a low brick building (only two bricks thick or 8 inches) is sometimes less effective than a 15-inch thick, nonload bearing, light-clad wall of a high-rise framed structure.

8-62. Individual Soldiers/Marines are also concerned about the amount of overhead protection available. Therefore, Soldiers/Marines need to know about the properties of roof, floor, and ceiling materials. These materials vary with the type of building construction. In brick buildings, the material for the ceiling of the top floor is far lighter than that for the next floor down that performs as both ceiling and floor, and thus is capable of holding up the room's live load.

Machine Gun Positions

8-63. Machine guns are usually located on the ground floor to achieve grazing fire. In brick buildings, the lower floors have the thickest walls and thus the greatest degree of cover. In frame buildings, walls are the same thickness on every floor and thus the ground floor provides no advantage. Another consideration is the nature of the local terrain. Should a building selected for a machine gun position lie over the crest of a hill, grazing fire is sometimes not possible from a ground floor. In such cases, depending on the area's slope angle, grazing fire is achieved only from a higher floor.

Antitank Weapon Positions

8-64. The positioning of AT weapons within buildings demands consideration of the critical need for cover. Buildings with fairly thick walls have rooms that are too small to permit firing of heavy AT weapons, such as the TOW. Therefore, only light AT weapons such as the AT4 are fired from inside

buildings. When AT weapons are fired, backblast is present and minimum room size must be adhered to as shown in table 8-4.

Table 8-4. Minimum floor sizes for firing weapons in enclosed areas

Weapons	***Minimum Floor Size (feet)***	
	Frame	***Masonry***
TOW	20 by 32	20 by 20
Javelin	8 by 8	8 by 8
AT4	7 by 12	Minimum of 4 ½ feet to back wall
Legend: TOW – tube-launched optically-tracked wire-guided		

8-65. When weapons are fired in enclosed areas in structures, the following conditions are required:

- The area must have a ceiling at least 7 feet high. Minimum floor sizes by weapon and type of construction are as shown in table 8-4.
- About 20 square feet of ventilation is necessary to the rear of the weapons. An open door normally provides adequate ventilation.
- Small, loose objects and window/door glass are removed from the firing area.
- Combustible material is removed from behind the weapon. Curtains and overstuffed furniture out of the blast area are usually left in place to help absorb sound.
- For ATGMs, vertical clearances between the bottom of the launch tube and the wall opening are 6 inches for TOW and 12 inches for Javelin. Given a requirement for rotation and a wide field of fire, light-clad framed buildings may need to be selected to account for backblast.
- Occupants must be forward of the rear of the weapon and wear helmets and earplugs.

Antiaircraft Weapon Positions

8-66. The deployment of antiaircraft weapons can also be related to a consideration of building characteristics. An ideal type of building for such deployment is a modern parking garage (one with rooftop parking). It offers sufficient cover, a circulation pattern favoring such weapons carried on light vehicles, and frequently offers good line of sight.

Other Planning Considerations

8-67. Fighting and protective positions located inside urban buildings sometimes require upgrade or reinforcement. Before planning building modification, consider the—

- Availability of materials such as fill for sandbags.
- Transportability of materials up stairwells and into attics.
- Structural limitations of attics and upper level floors (dead-load limitations).

Considerations for Camouflage and Concealment

8-68. Urbanization is reducing the amount of open, natural terrain throughout the world. Therefore, modern military units must be able to apply effective urban camouflage and concealment. Many of the camouflage and concealment techniques used in natural terrain are effective in urban areas.

Planning

8-69. Planning for operations in urban areas presents unique difficulties. Tactical maps do not show manmade features in enough detail to support tactical operations. Therefore, they must be supplemented with aerial photographs and local city maps. Local government and military organizations are key sources

of information that can support tactical and camouflage and concealment operations. They can provide diagrams of underground facilities, large-scale city maps, and civil-defense or air-raid shelter locations.

Selecting a Site

8-70. The physical characteristics of urban areas enhance camouflage and concealment efforts. The dense physical structure of these areas generates clutter (an abundance of EM signatures in a given area) that increases the difficulty of identifying specific targets. Urban clutter greatly reduces the effectiveness of a threat's surveillance sensors, particularly in the infrared and radar wavelengths. Urban terrain, therefore, provides an excellent background for concealing CPs, reserves, logistics complexes, or combat forces. The inherent clutter in urban terrain generally makes visual cues the most important consideration in an urban camouflage and concealment plan.

8-71. The regular pattern of urban terrain; the diverse colors and contrast; and the large, enclosed structures offer enhanced concealment opportunities. Established, hardened road surfaces effectively mask vehicle tracks. Depending on the nature of the operation, numerous civilian personnel and vehicles may be present and may serve as clutter. This confuses an enemy's ability to distinguish between military targets and the civilian population. Underground structures (sewers, subways) are excellent means of concealing movement and critical assets.

8-72. When augmented by artificial means, manmade structures provide symmetrical shapes that provide ready-made camouflage and concealment. The camouflage and concealment for fighting positions is especially important because of the reduced identification and engagement ranges (100 meters or less) typical of urban fighting. Limit or conceal movement and shine. These signatures provide the best opportunity for successful threat surveillance in urban terrain. Careful placement of equipment and fighting positions remains important to provide visual camouflage and concealment and avoid detection by contrast (thermal sensors detecting personnel and equipment silhouetted against colder buildings or other large, flat surfaces).

Establishing Fighting Positions

8-73. The fundamental camouflage and concealment rule is to maintain the natural look of an area as much as possible. Buildings with large, thick walls and few narrow windows provide the best concealment. When selecting a position inside a building, Soldiers/Marines should—

- Avoid lighted areas around windows.
- Stand in shadows when observing or firing weapons through windows.
- Select positions with covered and concealed access and egress routes (breaches in buildings, underground systems, trenches).
- Develop decoy positions to enhance camouflage and concealment operations.

Placing Vehicles

8-74. Hide vehicles in large structures, if possible, and use local materials to help blend vehicles with the background environment. Paint vehicles and equipment a solid, dull, dark color. If you cannot do this, use expedient paints to subdue the lighter, sand-colored portions of the standard camouflage screening paint patterns. When placing vehicles outdoors, use shadows for concealment. Move vehicles during limited visibility or screen them with smoke.

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Appendix A
Entry Control Points

A common tactic used against base camps and other sites is the use of VBIEDs and suicide attacks, which can produce large numbers of casualties. Because of these enemy tactics, it is important to design and emplace facilities that detect or deter these methods of attack, especially at the entrance to base camps and critical infrastructure locations. Properly designed ECPs protect the facility and personnel occupying the ECP while allowing for organized and efficient traffic flow. A well-organized ECP minimizes confusion and allows the rapid flow of vehicles and personnel while minimizing the threat of attack. This appendix provides a brief overview of ECP design. Additional details are in GTA 90-01-011, GTA 90-01-018, and UFC 4-022-01.

SITE SELECTION CRITERIA

A-1. Development of a new ECP, and improvement of existing ECPs, begins with an evaluation of the—

- Anticipated traffic volume.
- Interface with the surrounding road network.
- Threat environment.
- Terrain available to accommodate design features.
- Availability, quantity, and proficiency of local national security guards.

VEHICLE TRAFFIC

A-2. Vehicles entering and exiting the ECP must be controlled with simple features and clear instructions. ECP design, including adequate turning dimensions, employment of barriers, and procedures required to meet security requirements should accommodate the largest class of vehicle requiring entry into the base camp. Space permitting, ECPs should have multiple lanes for separating oversized vehicles, military vehicles, and commercial vehicles. Separation of those vehicles recognizes differences in size, placement of barriers, search requirements (risk), and the overarching need to meet throughput requirements while maintaining security.

PEDESTRIAN TRAFFIC

A-3. ECP design should direct pedestrian traffic to a specified walkway that is separate from vehicular traffic. Separation of vehicle traffic and pedestrian traffic affords a control measure to mitigate the effects of a VBIED attack. Pedestrian walkways should be designed to allow continuous surveillance of pedestrians transiting the ECP.

OPERATIONAL PRINCIPLES

A-4. Design should be driven by the observance of the eight ECP operational principles described in GTA 90-01-018. This will enable ECP personnel to maintain appropriate traffic throughput and adequate security. Those principles are—

- **Security.** Effective security design will enable control over individuals, objects, and activities to prevent unauthorized access into, and enemy attacks against, the base camp. Security design should include provisions for multiple overwatch positions, EAs, and the employment of random antiterrorism measures.

- **Early warning.** ECP design should enhance early warning by incorporating compliance measures and sensors to provide indications of potential threat activity.
- **Standoff.** ECP design should maximize standoff by—
  - Incorporating the placement of barriers.
  - Slowing, restricting, and metering/controlling the advance of individuals and vehicles.
  - Increasing the time available to observe and assess a potential threat.
  - Providing multiple opportunities for the threat to display compliance or noncompliance.
  - Providing physical protection to ECP personnel and host nation security forces.
- **Identification.** ECP design should create compliance measures to assist in identifying and discriminating between authorized and unauthorized individuals.
- **Segregation.** ECP design should physically separate different types of traffic. When possible, the design should separate military vehicles, types/classes of civilian vehicles, and pedestrian traffic.
- **Mitigation.** ECP design should incorporate materials and technologies to reduce the effectiveness of enemy tactics used to observe, plan, and execute attacks. Designs should—
  - Limit the ability of the enemy to observe ECP operations.
  - Reduce or neutralize the effects of explosions.
  - Reduce or limit personnel exposure by compartmentalizing areas.
  - Include adequate physical protection for each Soldier/Marine operating the ECP.
- **Capacity.** ECP design should facilitate efficient throughput while maintaining adequate security. Design, materials, and technologies should control the speed of vehicles and pedestrians moving through the ECP through the use of speed bumps, serpentines, turnstiles, or other control measures. However, this should be done in a way that does not make individuals waiting to enter the ECP more vulnerable to attack.
- **Simplicity.** Simplicity of design will permit ECP leadership and personnel to execute complex tasks, especially during high-stress escalation of force incidents and attacks. A simple design should incorporate—
  - Standoff.
  - A detailed obstacle plan.
  - Overwatch positions and EAs.
  - Clear and unambiguous directions for personnel transiting the ECP.
  - Redundancy in power, critical communications, and sensor systems.

OPERATIONAL ZONES AND PHASES

A-5. The ECP should be divided into three functional zones, each having specific purposes and functions. Those zones correspond to the operational phases outlined in GTA 90-01-018 and depicted in figure A-1. Furthermore, design should incorporate a defense-in-depth concept establishing primary and alternate fighting positions for ECP personnel. The zones and phases are designed to give ECP personnel references for distance and time.

APPROACH ZONE

A-6. As individuals and vehicles depart the public road network and enter the military controlled area outside the base camp, they enter the approach zone, which is the beginning of the ECP's defense-in-depth. The principal purposes of the approach zone are to provide standoff and early warning to control incoming traffic. The approach zone design should include obstacles and compliance measures to—

- Separate the different types of traffic.
- Restrict speed and movement.
- Protect vehicles and personnel inside the zone from external dangers.
- Protect individuals and vehicles from friendly fire.

- Provide audio and visual warnings to alert approaching individuals.

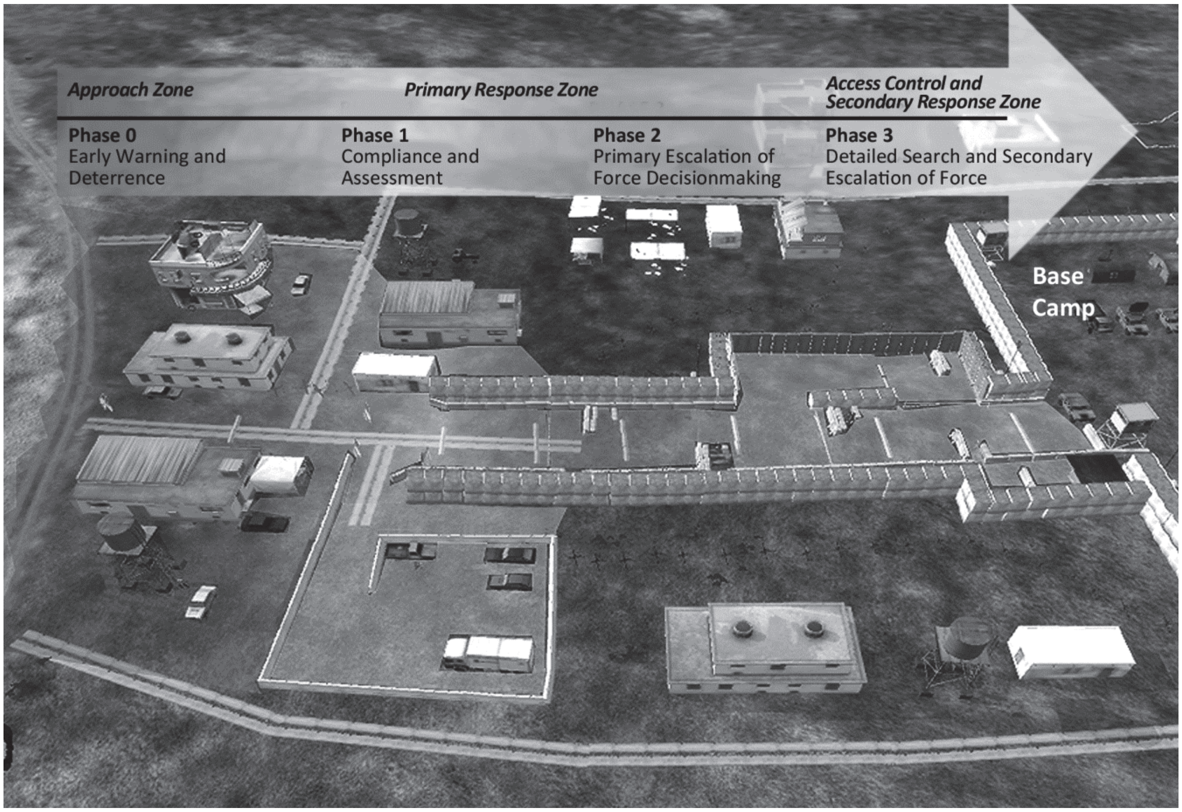

Figure A-1. Operational phases for ECPs

PRIMARY RESPONSE ZONE

A-7. The primary response zone is designed as the ECP's EA for escalating force. ECP design for the primary response zone should enable—

- Integration of protective obstacles to improve survivability for all personnel.
- Emplacement of obstacles to block vehicles and prevent entry.
- Direct fire from overwatching crew-served weapons.
- Continuous assessment of potential threats.

ACCESS CONTROL AND SECONDARY RESPONSE ZONE

A-8. Design of the access control and secondary response zone includes fighting positions, vehicle and personnel inspection areas, and an access validation area. The design should ensure that the infrastructure can support the appropriate amount of throughput and enable—

- Detailed searches.
- Access validation.
- Escalation of force.

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Appendix B
Reachback Tools

This appendix is designed to highlight some of the support resources for engineers performing survivability operations. These resources include the United States Army Corps of Engineers (USACE), the USAES, the Army Facilities Component System (AFCS), the Simplified Survivability Assessment (SSA), and the Antiterrorism Planner. This type of reachback capability is one of the characteristics of field force engineering (FFE). The Air Force and Navy provide some of the same type of capabilities and support through the Air Force Civil Engineering Support Agency and the Naval Facilities Engineering Command. See FM 3-34 for further information.

UNITED STATES ARMY CORPS OF ENGINEERS

B-1. The USACE is the Army's direct reporting unit assigned responsibility to execute Army and DOD military construction, real estate acquisition, and development of the nation's infrastructure through the civil works program. Most of its assets are part of the generating force (see FM 1-01), but selected elements are part of the operational Army.

B-2. USACE has aligned its divisions with and assigned liaison officers to combatant and Army commanders to enable access to USACE resources to support engagement strategies and wartime operations. The USACE mission supports the following five major functions:

- Military support—provides engineering and contingency support for unified land operations.
- Disasters—responds to and supports recovery from local, national, and global disasters.
- Infrastructure—acquires, builds, and sustains critical facilities for military installations, theater support facilities, and public works.
- Environment—restores, manages, and enhances ecosystems, local and regional.
- Water resources development—balances requirements between water resources development and the environment.

B-3. USACE support provides for technical and contract engineering support, integrating its organic capabilities with those of other Services and other sources of engineering-related reachback support. Whether providing construction contract and design support in the AO or outside of the contingency area, USACE can obtain necessary data, research, and specialized expertise not present in theater through reachback capabilities using tele-engineering when necessary. Tele-engineering is the communications architecture that facilitates reachback when the existing communications infrastructure will not support it. Tele-engineering is under the proponency of the USACE and is inherent in FFE. Tele-engineering can provide valuable support for planning survivability missions.

B-4. USACE is the primary proponent of FFE and related generating force support which enable engineer support to the operational Army. FFE is the application of the Engineer Regiment's capabilities from the three engineer disciplines (although primarily general engineering) through both reachback and forward presence. It enables generating force engineer support to deployed operating forces and is provided by technically specialized personnel and assets (deployed and participating through reachback) or through operational force engineer Soldiers/Marines linked to reachback capabilities. The FFE concept is applicable in joint and multinational operations to provide technical engineer solutions that can be implemented faster and with a smaller footprint. The U.S. Air Force and the U.S. Navy have similar capabilities—the Air Force uses its Geo-Reach program while the Navy (and Marine Corps) has the capability to conduct engineer reconnaissance with reachback to the Naval Facilities Engineering Command.

B-5. One of the ways USACE supports FFE is by training, equipping, and maintaining specialized deployable FFE teams that execute the USACE mission in the AO. FFE teams are usually subordinate to the senior engineer commander in the AO and provide additional military and civilian engineering expertise that can support survivability missions. USACE also provides support through nondeployable teams that can be accessed by reachback. These teams, whether deployed or supporting via tele-engineering, can provide valuable assistance in the planning and design of survivability measures. (See FM 3-34 and Engineer Pamphlet 500-1-2 for additional information about FFE teams.)

ENGINEER RESEARCH AND DEVELOPMENT CENTER

B-6. USACE operates the United States Army Engineer Research and Development Center (ERDC), a comprehensive network of laboratories and centers of expertise. Research projects include facilities, airfields and pavements, protective structures, sustainment engineering, environmental quality, installation restoration (cleanup), compliance and conservation, regulatory functions, flood control, navigation, recreation, hydropower, topography, mapping, geospatial data, winter climatic conditions, oceanography, environmental impacts, and information technology. ERDC developed and is the point of contact for the SSA program and also provides users with the Antiterrorism Planner (see below).

UNITED STATES ARMY CORPS OF ENGINEERS REACHBACK OPERATIONS CENTER

Description

B-7. The UROC provides a reachback engineering capability enabling DOD personnel deployed worldwide to talk directly with experts in the United States when a problem in the field needs quick resolution. Deployed troops can be linked to subject matter experts within the government, private industry, or academia to obtain solutions to complex field problems. The UROC can be contacted at 1-877-ARMY-ENG or 601-634-2439; Defense Switched Network (DSN) 312-446-2439; e-mail: <uroc@usace.army.mil> (secure e-mail: <uroc@usace.army.smil.mil>). Their Web site is <https://uroc-redi.usace.army.mil> (secure Web site is <http://uroc.usace.army.smil.mil>).

Capabilities

B-8. The UROC responds to incoming information requests—such as flooding potential due to dam breaches; load-carrying capacities of roads and bridges; field fortifications and other protective structures; design and repair of airports, port facilities, bridges, dams, railroads and roadways; and evaluation of transportation networks. The UROC provides comprehensive training and support to deployed units and maintains a data repository for collected engineering data used for infrastructure analysis.

Supporting Technology

B-9. The tele-engineering communication equipment provides reachback capability using off-the-shelf satellite communications equipment with added security encryption. Video teleconferences and data transfers can be conducted from remote sites where normal communications are unavailable.

B-10. The tele-engineering toolkit (TETK) software is a valuable analysis tool for the graphical display of engineer products, analyses, and digital data. The automated route reconnaissance kit (ARRK) combines the power of the TETK with global positioning system, video camera and 3-dimensional accelerometer to provide an automated route reconnaissance capability (mounted vehicle or airborne). This system has supported numerous military operations and natural disaster response missions.

B-11. The geospatial assessment tool for engineering reachback (GATER) provides rapid data collection for assessing critical infrastructure, real property, environmental condition reports, environmental base closures, real estate lease, access control points, explosive ordnance disposal, civil affairs, and special operations weather team collections. The UROC provides comprehensive training and support to units and maintains a repository for collected data and data migration to secure networks.

SERVICE ENGINEER SCHOOLS

B-12. In the Army, the engineer doctrine section of the Maneuver Support Center of Excellence consolidated doctrine division manages engineer doctrine within the Training and Doctrine Command doctrine development cycle. As part of this process, USAES assesses plans and develops, produces, and disseminates engineer doctrine that is synchronized with allied, multinational, joint, multi-Service, and combined arms doctrine. USAES supports the development of nonengineer doctrinal products by providing subject matter expertise for review and coordination, and supports the Engineer Regiment by managing the Center for Engineer Lessons Learned and providing information and analysis as needed.

B-13. The Marine Corps Engineer School provides reachback for Marine Corps engineers and operating forces. The school provides engineers with doctrinal, educational, historical, and technical support to operational forces. Marine Corps units have the capability to conduct engineer reconnaissance with reachback to the Naval Facilities Engineering Command and USACE.

ARMY FACILITIES COMPONENTS SYSTEM

B-14. The AFCS provides support to engineers and DOD mission partners worldwide. AFCS is used for planning, design, and management of contingency construction missions in a theater of operations and for emergency construction support during disaster relief operations. The AFCS design data repository currently contains numerous facility designs, component designs, and drawings. Some of the designs include base camps; barracks; latrines; containerized housing units; roads; administrative facilities; hospitals; power facilities; petroleum storage and distribution facilities; and ammunition storage facilities.

B-15. The AFCS desktop application is TCMS—a planning, design, management, and reporting system used by military planners, supply agency personnel, and construction personnel who have a role in providing Army facilities for contingency construction activities outside the continental United States. Distribution of TCMS is available upon request to all U.S. military engineer units.

Note. Additional information about TCMS, including training, can be accessed at <www.tcms.net>.

SIMPLIFIED SURVIVABILITY ASSESSMENT

B-16. The SSA is a software tool, developed by the ERDC, that provides a suite of tools and information on the design, construction, and planning of survivability positions that are useful for combat engineers and planners. The SSA provides a database of survivability positions including asset requirements, construction time estimates, drawings, pictures, construction guidance, and more. These positions expand on the material in this manual and include additional material for positions designed by ERDC.

B-17. The SSA also features a planning module for estimating construction times for a detailed plan of survivability positions grouped by mission and task and based on a set of equipment assets. The estimates include factors for night work, soil type, downtime, refueling, and crew size. Users can specify priorities and easily set up alternate plans by selecting/deselecting different mixes of tasks and assets.

B-18. The hand-calculation method of designing overhead cover is replaced by a simple wizard format. Users can choose from four design modes to determine the stringer length, spacing, the soil depth, or the level of protection, given the other inputs.

B-19. Finally, the SSA compact disk comes bundled with the latest Windows version of the conventional weapons effects software tool for quickly assessing weapons effects. Users can estimate the air blast pressure at a given distance from a weapon detonation or calculate the explosive weight for given crater dimensions. Other calculations available include fragment and projectile penetration, ground shock, internal air blast, and loads on structures. For more information regarding SSA, contact the UROC (see paragraph B-7).

ANTITERRORISM PLANNER

PURPOSE

B-20. The Antiterrorism Planner is a software tool based on threat, mission, and site considerations and is designed to assist commanders in planning, implementing, and evaluating protective measures; expediting structure designs; and providing standoff guidance required for antiterrorism/survivability.

CAPABILITIES

B-21. The Antiterrorism Planner provides the user with a computerized analysis tool for evaluating critical assets in terrorist threat scenarios based on aggressors, tactics, and weapons systems. The threat conditions dictate a number of security measures from this manual that the user must consider and possibly employ. These measures are cumulative from the lowest to the highest threat level and are presented in the Antiterrorism Planner in a concise format. Emphasis has been placed on the evaluation of structural components, windows, personnel, and other limited critical assets. Structural components are defined for frames, walls, and roofs from common construction materials. Damage to the building components is calculated using algorithms from the Facility and Component Explosive Damage Assessment Program, with the user providing the distance of the explosive charge from the building.

B-22. The Antiterrorism Planner can also provide the required standoff for a given explosive charge. Once the appropriate standoff is determined, based on the expected explosive size and an acceptable level of building damage, the Antiterrorism Planner provides information on protective barriers and a vehicle velocity calculator to aid in barrier and obstacle selection. Extensive information is available on various types of obstacles and protective barriers, and the information source is referenced. In addition, the Antiterrorism Planner provides a basis for design and analysis of wall and window retrofits. The capability is available to view facility or site images, locate assets on the site image, and show building damage in two- and three-dimensional graphical formats. Blast walls can be placed in front of structures, and the resulting damage to a protected building is then calculated. Glass hazard calculations have been incorporated along with user-defined pressure-impulse curves to give engineers more flexibility in evaluating structures.

B-23. The Antiterrorism Planner contains algorithms to estimate injuries and fatalities to occupants of structures to provide consequences of terrorist attack for the antiterrorism program. The Antiterrorism Planner can be obtained by contacting the UROC (see paragraph B-7).

Appendix C

Example Survivability Capabilities and Tracking Tools

The ability to communicate capabilities to a supported commander is critical for the commander's decisionmaking process. Capabilities are analyzed and assessed at each phase of an operation from planning through execution. Most capabilities are analyzed and presented to the maneuver commander as part of the engineer running estimate. The running estimate is a living document. As changes occur within the engineer structure (such as task organization changes, equipment availability due to maintenance) or to other conditions that may affect the estimate (such as changes in timeline or weather conditions), the capabilities assessment must also change. Determining a method to communicate these capabilities to the maneuver commander in a fashion that is meaningful or useful is critical. This appendix provides a sample that an engineer can use to plan and communicate survivability capabilities while supporting operations. The sample may be modified to fit the type or size of the engineer unit supporting the maneuver force. This appendix also provides several techniques/tools used throughout the Army/Marine Corps to assist the engineer in tracking progress and keeping the commander and staff abreast of that progress. These examples (focused on survivability tasks) can be modified to fit any size or type of engineer unit, and are intended to keep leaders informed. These tracking tools may be updated at predetermined time intervals and passed to the engineer staff officer and supported commanders to keep them informed on the status and progress of the engineer work effort. When provided with this information, the commander possesses the flexibility to shift priorities to meet changing requirements and adjust to changing situations while optimizing the use of time and the available survivability capabilities.

ENGINEER CAPABILITIES CARD

C-1. The example capabilities card is focused on survivability effort potential. Normally survivability requirements will be competing against mobility and countermobility requirements. This tool tracks the current status and potential capabilities for employment against the commander's survivability priorities. Paragraphs C-3 through C-6 provide a discussion of how to track engineer (and other selected maneuver support) performance while executing essential tasks for M/CM/S and other tasks.

C-2. Table C-1, page C-2, provides a format to track survivability effort in a BCT/RCT, but can also be tailored to other echelons. This provides the engineer with a quick reference when discussing capabilities. It contains the most common pieces of equipment used in survivability preparation, and the most common materials available to harden facilities or vehicles. Users may adjust this format to fit individual needs or add items not currently on the card. This format will also assist the user in tracking maintenance availability for survivability resources.

Table C-1. Example survivability capabilities matrix

Equipment	*Assigned*	*Available*	NMC and Primary Fault	Blade-team Hours	TDP/12 Hours	*Tank Ditch*	*Meters Berm/12 Hours*	*Individual Fighting Positions*	*Crew-served Weapons Fighting Positions*	*Total*
D7 Dozer										
D5 Dozer										
M9 ACE										
M105 DEUCE										
Loaders										
SEE/HMEE/Backhoe										
SSL										
HYEX										
Crane										
Material	*Unit of Issue*	*Start Total*	*Used*	*Damaged*	*On Order*	*On Hand*				
Soil-filled Container										
Plywood										
2 by 4 Stud										
2 by 8 Stud										
4 by 4 Beams										
Corrugated Sheet Metal										
Concrete Barriers										
Jersey Barrier										
New York Barrier										
Texas Barrier										
Corrugated Metal Revetment Wall										
Plastic Soil Bin Wall										
E-Glass Sheets										
2-inch Foam Panel										
Chain Link (6 feet)										
Expanded Metal										
Welded Wire Mesh										
Other Resources										

Legend:
ACE – armored combat earthmover
DEUCE – deployable universal combat earthmover
HMEE – high-mobility engineer excavator
HYEX – hydraulic excavator
NMC – not mission capable
SEE – small emplacement excavator
SSL – skid steer loader
TDP – turret defilade position

USING COMMANDER'S CARDS

C-3. Commander's cards provide quick, detailed information to the commander in reference to engineer effort. Because the commander's time is limited, these cards should be easy to understand and provide accurate information. The engineer staff officer should portray effort available in comparison to effort executed. He should avoid providing commanders with raw data such as materials or blade hours. Instead, the engineer staff officer should consider providing numbers of positions or meters of berm available within the time allowed when discussing capabilities.

THE COMMANDER'S CARD CARTOON

C-4. Cartoons are a common method used to plan and track survivability effort. They are normally made using either a hand drawn representation of the AO or often a photocopied map sheet segment. Either method provides the commander a pictorial representation of the terrain, with a table portraying survivability effort planned versus executed. Several copies of this can be made and the staff engineer can update each with changes. Once the card is updated, the engineer can exchange the most recent card with the commander—providing the commander with the most current survivability status. See figure C-1.

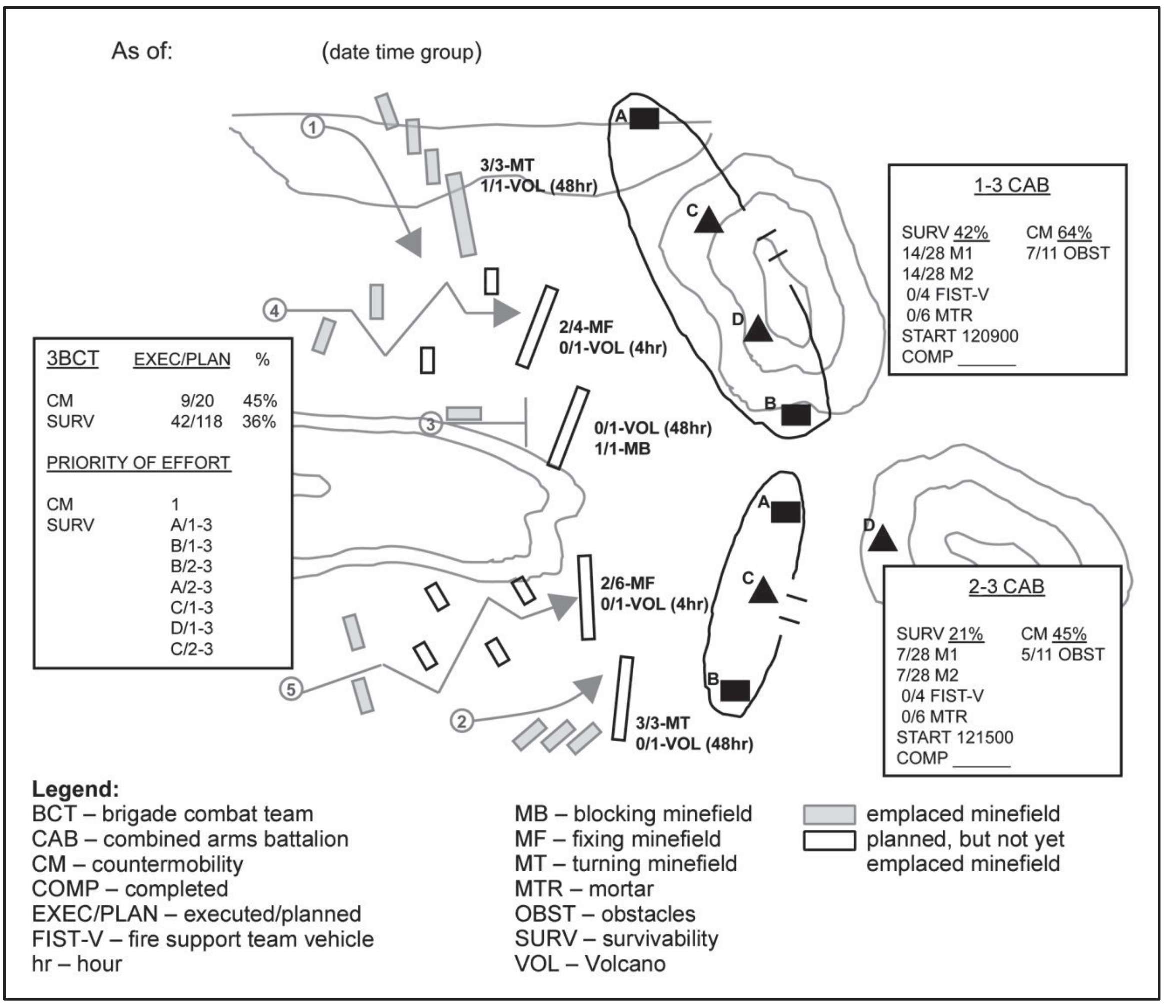
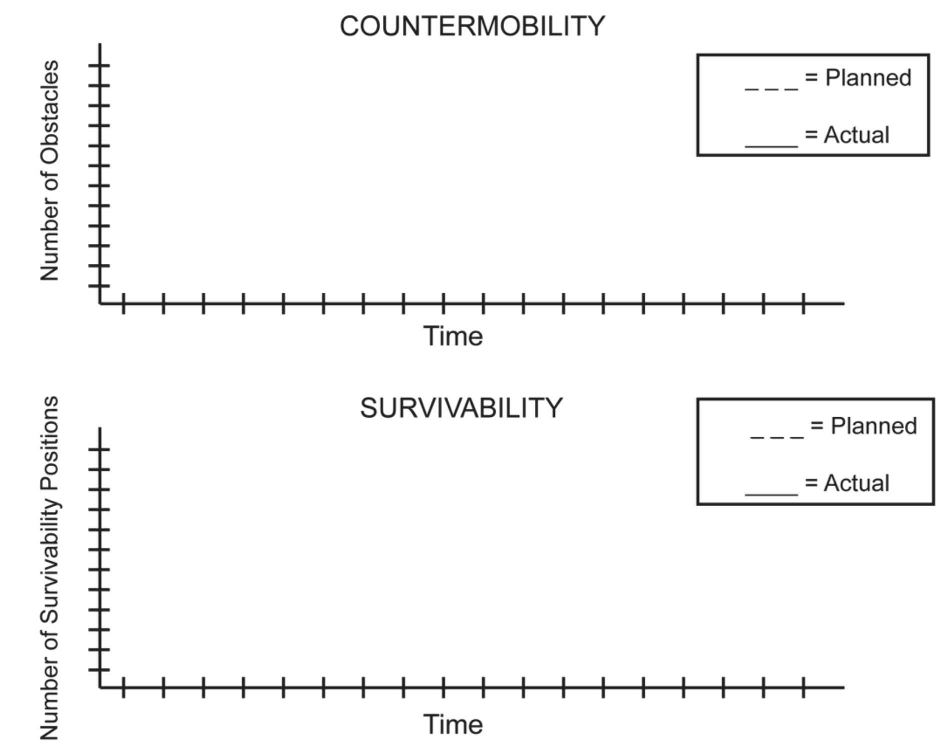


Figure C-1. Commander's card used to track M/CM/S effort in cartoon (sample)

COMMANDER'S CARDS

C-5. Commander's cards are another technique used to keep the commander informed. It is a survivability tracking tool in graph form which compares survivability effort planned to survivability effort executed over time. This method is effective because it quickly provides the commander information on the status in a constrained timeline and supports maintaining a running estimate. Again, this tool allows the commander to change priorities and make decisions regarding the survivability effort. These cards can combine M/CM/S information in the combat environment or focus purely on the survivability effort. The examples in figures C-2 and C-3 are intended (primarily) for use at the battalion and BCT/RCT levels.



Note**.**
The "Planned" line should be adjusted as conditions change; for example, changes in number of available blade teams and Class IV/V shortages.

Figure C-2. Example commander's card used to track countermobility and survivability effort in graphic sample

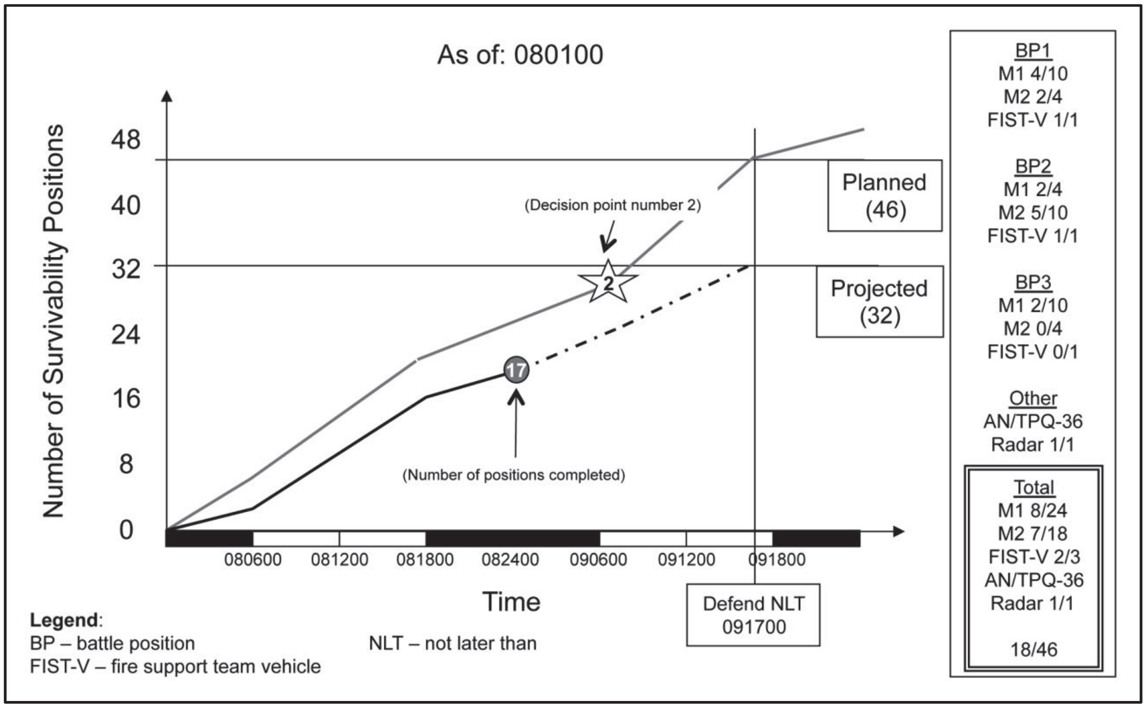
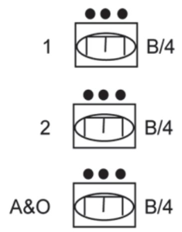


Figure C-3. Commander's card to track survivability effort (sample)

C-6. Commander's cards in table form are also a commonly used method. These provide raw numbers for the commander but have no pictorial representation of the terrain. They are effective in understanding resources available to the commander. This type of card is more commonly used in engineer headquarters to track and report material available. See figure C-4, page C-6.

TASK ORGANIZATION



COUNTERMOBILITY

Class IV/V	TF Plan	BCT On-Hand	Used	% Used	Capability by time
Mines	344	1725	867	50%	1470
Concertina Wire	960	2300	437	19%	1200
Long Pickets	1500	2750	463	17%	1200

RESOURCES

Assets	Status
Squads	6/6
M113s	8/9
M548	1/2
Volcano	1/2
V. Loads	
MOPMS	6/6
Hornet	10/10
Dozers	1/4
SEEs	1/2

SURVIVABILITY

Positions	Planned	Executed	To Std	% To Std	Capability
M1 Hull	16	9	0	0%	**CBT VEH** 27 **INDIV** 62 or **CREW** 31
M2 Hull	28	26	4	15%	
FIST-V	0	2	2	100%	
Individual	0	6	0	0%	
Crew					
Total	44	43	6	14%	

Legend:
A&O – assault and obstacle
BCT – brigade combat team
CBT VEH – combat vehicle
FIST-V – fire support team vehicle
INDIV – individual
MOPMS – modular pack mine system
SEE – small equipment excavator
Std – standard
TF – task force
V – Volcano

Figure C-4. Commander's card to track countermobility and survivability (table) (sample)

Appendix D

Bunker and Shelter Roof Design

This appendix provides designs, procedures, and tabular data for roof cover systems used to defeat a contact burst HE projectile. It describes a simplified procedure for using wood as the material for a standard stringer roof. A more detailed procedure is provided for using other materials (such as steel or another material). While the calculations are lengthy, they are basically simple. The two example problems in this appendix were worked with a handheld calculator, and the complete digital display is listed. This listing enables a complete step-by-step following without the slight numerical variation caused by rounding. In reality, rounding each result to three significant digits will not significantly alter the outcome. (See Technical Report N-76-7 for the empirical data upon which these procedures are primarily based. See UFC 3-340-01 or contact the UROC [see appendix B] for additional information or assistance with roof design for hardened structures.)

BASIC ROOF DESIGN

D-1. The standard stringer roof design is shown in figure D-1. The roof design discussed here is for a simple stringer roof of single-ply or laminated sheathing covered with earth.

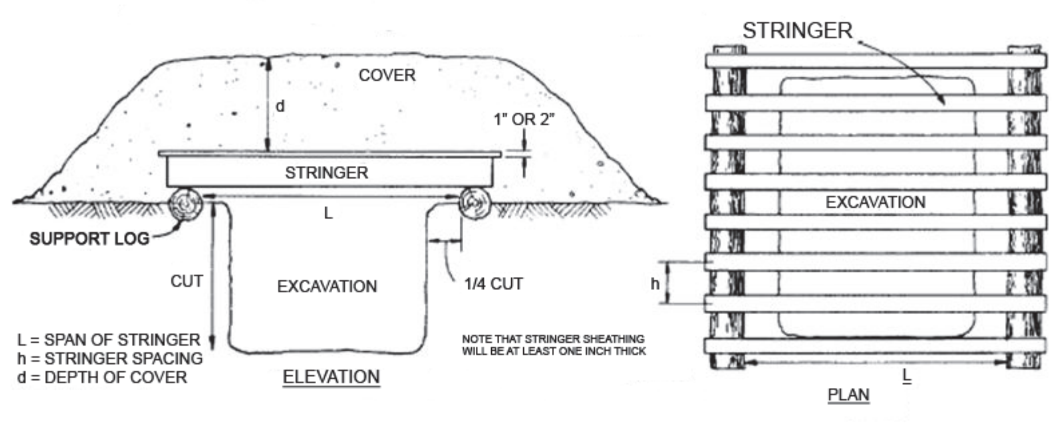


Figure D-1. Basic roof design for a simple stringer roof

DESIGN DATA REQUIREMENTS

D-2. The following data is required to complete the design:

- Soil parameters.
- Available stringer materials, dimensions, and orientation (stringer characteristics).
- Size (in millimeters) and type of round (superquick or contact burst) the roof must defeat.
- Depth of soil cover.

Soil Parameters

D-3. Two soil parameters are needed in the design procedure—unit weight and soil-impulse-to-structure transmission coefficient. Soil unit weight must be determined at the time and place of design. Both the soil type and its water content affect unit weight. Soil unit weight is usually 80 to 140 pounds per cubic foot. The transmission coefficient can be taken from table D-1. The range of transmission coefficients in table D-1 are from limited HE tests and show the variability of soil-structure response. Higher soil density and moisture content increases the impulse load on the structure. For example, damp compacted cohesive cover material should not be used since it will not attenuate the blast shock wave as well as dry loosely placed sand. Gravel is not recommended for cover material because the blast creates secondary missiles of gravel.

Table D-1. Transmission coefficient for different soil types

Material	*Soil Type*	*Transmission Coefficient (C)*[1]
sand, poorly graded (SP)	Loose, clean, white mason sand	260 - 700
SP	Loose, tan, pit-run sand	60 - 475
SP	Loose, red, pit-run gravelly sand	75 - 320
SP	Bagged, pit-run sand	130 - 140
gravel, poorly graded (GP)	Washed gravel, rounded	120
silt, low plasticity (ML)	Loose, sandy silt	125 - 275
ML	Compacted, sandy silt	350

Note.
For additional information on soil types, see FM 5-472.
[1]Because the impulse response characteristics of the various earth materials and transfer of blast shock from the cover material to the structural roof system are so varied and dependent on many factors (such as density, moisture content, cohesiveness, porosity, grain size and distribution), the larger transmission coefficient for a given material and soil type should be used to provide a more conservative design. For example, use a transmission coefficient of 700 for poorly graded sand (loose, clean, white mason sand).

Stringer Characteristics

D-4. Values for several stringer characteristics must be used in the design procedure: the moment of inertia, section modulus, modulus of elasticity, and maximum dynamic flexural stress. For wood stringers these values are given in figure D-2, table D-2, and table D-3.

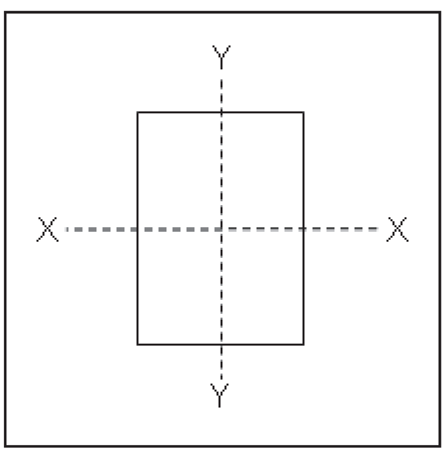


Figure D-2. Axis orientation, timber

Table D-2. Moment of inertia and section modulus for different timber sizes

		X-X Axis		Y-Y Axis	
Nominal Size (inches)	***Actual Size (inches)***	***Moment of Inertia (I) (inches^4)***	***Section Modulus (S) (inches^3)***	***Moment of Inertia (I) (inches^4)***	***Section Modulus (S) (inches^3)***
2 by 4	1 ½ by 3 ½	5.36	3.06	0.98	1.31
2 by 6	1 ½ by 5 ½	20.80	7.56	1.55	2.06
2 by 8	1 ½ by 7 ¼	47.64	13.14	2.04	2.72
2 by 12	1 ½ by 11 ¼	177.98	31.64	3.16	4.22
4 by 4	3 ½ by 3 ½	12.51	7.15	12.51	7.15
4 by 6	3 ½ by 5 ½	48.53	17.65	19.65	11.23
4 by 8	3 ½ by 7 ¼	111.15	30.66	25.90	14.80
6 by 6	5 ½ by 5 ½	76.26	27.73	76.26	27.73
6 by 12	5 ½ by 11 ½	697.07	121.23	159.44	57.98
6 by 14	5 ½ by 13 ½	1,127.67	167.06	187.17	68.06
8 by 8	7 ½ by 7 ½	263.67	70.31	263.67	70.31
10 by 10	9 ½ by 9 ½	678.76	142.90	678.76	142.90

Note.
Axis orientation is as shown in figure D-2.

Table D-3. Modulus of elasticity and maximum dynamic flexural stress for different timber species

Timber Species	***Modulus of Elasticity (E) (10^6 pounds per square inch)***	***Maximum Dynamic Flexural Stress (FS) (pounds per square inch)***
Cedar	1.10	2,200
Douglas fir	1.76	4,000
White fir	1.21	2,200
Eastern hemlock	1.21	2,600
Western hemlock	1.54	3,200
Larch	1.76	4,600
Southern pine	1.76	6,000
Ponderosa pine	1.10	1,800
Redwood	1.32	3,400
Spruce	1.10	2,900

D-5. For steel stringers the values for inertia and section modulus are given in table D-4 and figure D-3, page D-4. For steel stringers use modulus of elasticity = 29 and maximum dynamic flexural stress = 50,000. (Additional structural design data is available in the appendixes of FM 3-34.343/MCRP 3-17.1B).

Table D-4. Moment of inertia and section modulus for different steel wide flange members

	X-X Axis		*Y-Y Axis*	
Nominal Size (inches)	***Moment of Inertia (I) (inches^4)***	***Section Modulus (S) (inches^3)***	***Moment of Inertia (I) (inches^4)***	***Section Modulus (S) (inches^3)***
36 by 16 ½	14,988.4	835.5	870.9	105.7
36 by 12	9, 012.1	502.9	250.9	41.8
33 by 11 ½	6,699.0	404.8	201.4	35.0
30 by 15	7,891.5	528.2	550.1	73.4
30 by 10 ½	4,461.0	299.2	135.1	25.8
27 by 10	3,266.7	242.8	115.1	23.0
24 by 12	2,987.3	248.9	203.5	33.9
24 by 9	2,096.4	175.4	76.5	17.0
21 by 8 ¼	1,326.8	126.4	53.1	12.9
18 by 7 ½	800.6	89.0	37.2	9.9
16 by 7	446.3	56.3	22.1	6.3
14 by 6 ¾	289.6	41.8	17.5	5.2
12 by 12	533.4	88.0	174.6	29.1
12 by 6 ½	204.1	34.1	16.6	5.1
10 by 10	272.9	54.6	93.0	18.6
10 by 5 ¾	106.3	21.5	9.7	3.4
8 by 8	109.7	27.4	37.0	9.2
8 by 6 ½	82.5	20.8	18.2	5.6
8 by 5 ½	56.4	14.1	6.7	2.6
6 by 6	53.5	16.8	17.1	5.6
4 by 4	11.3	5.45	3.76	1.85
Note. Axis orientation is as shown in figure D-3.				

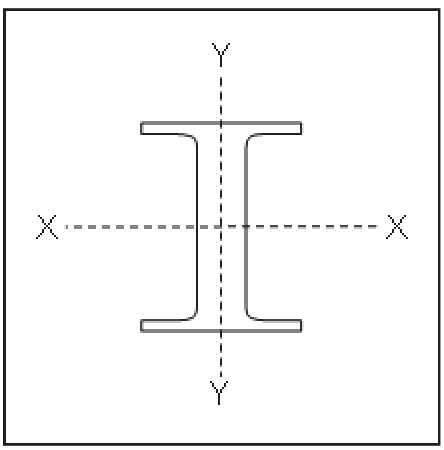


Figure D-3. Axis orientation, steel wide flange members

D-6. Table D-5 provides the thickness of wood sheathing for a given span length and thickness of earth cover. Longer spans and thicker earth cover will require a greater thickness of wood sheathing.

Table D-5. Maximum span of dimensioned wood roof sheathing for earth cover

Thickness of Earth Cover (feet) (Based on Material Thickness Required for Shielding)	*Span Length (feet)*					
	2 ½	*3*	*3 ½*	*4*	*5*	*6*
	Wood Thickness (inches)					
1 ½	1	1	2	2	2	2
2	1	2	2	2	2	3
2 ½	1	2	2	2	2	3
3	2	2	2	2	3	3
3 ½	2	2	2	2	3	3
4	2	2	2	2	3	4

D-7. Table D-6 provides information on the maximum center-to-center stringer spacing, based on stringer size and earth cover. The greater the thickness of the earth cover, the smaller the stringer-to-stringer spacing for a given stinger dimension. Note that at certain points on the table, the required stringer size increases to 2 by 6 (minimum).

Table D-6. Maximum span of wood stringer roof support for earth cover

Thickness of Earth Cover (feet)	*Span Length (feet)*					
	2 ½	*3*	*3 ½*	*4*	*5*	*6*
	Center-to-Center Spacing (inches)					
1 ½	40	30	22	16	10	18*
2	33	22	16	12	8/20*	14*
2 ½	27	18	12	10	16*	10*
3	22	14	10	8/20*	14*	8*
3 ½	18	12	8/24*	18*	12*	8*
4	16	10	8/20*	10*	10*	7*

Note.
Stringers are 2 by 4s (or minimum 5-inch diameter round timber) except those marked by an asterisk (*) which are 2 by 6s (or minimum 7-inch diameter round timber).

D-8. Table D-7 pertains to steel pickets and landing mats for roof supports (for fragment shielding only). When roof structures are designed to defeat contact bursts of HE projectiles, substantial additional roof protection is required.

Table D-7. Maximum span of steel picket roof supports for sandbag layers

Number of Sandbag Layers	*Span Length (feet)*		
	3	*6*	*9*
	Center-to-Center Spacing (inches)		
Single-Picket Beams[1]			
2	7	7	6
5	6	5	4
10	4	4	3
15	4	3	2
20	3	3	2

Table D-7. Maximum span of steel picket roof supports for sandbag layers (continued)

Double-Picket Beams[2]			
2	7	7	7
5	7	7	7
10	7	6	5
15	7	5	4
20	6	5	4

Note.
Use in conjunction with steel landing mat sheathing.
[1] Used with open side down.
[2] Two pickets are welded together every six inches along the span to form box beams.

DESIGN PROCEDURES

D-9. The two basic procedures in bunker and shelter roof design are—

- Simplified design.
- Detailed design.

SIMPLIFIED DESIGN PROCEDURE

D-10. When designing wood stringer-supported roofs to defeat contact bursts of certain-sized munitions, the simplified design procedure can be used. It uses table D-8, which lists solutions calculated by the detailed design procedure. Enter the table with stringer data, cover data, and munitions type projected for contact burst to determine center-to-center stringer spacing.

Table D-8. Center-to-center spacing for wood supporting soil cover to defeat contact bursts

Nominal Stringer Size (inches)	***Depth of Soil (d) (feet)***	***Center-to-Center Stringer Spacing (h) (inches), for Cited Span Length (l) (feet)***				
		2	***4***	***6***	***8***	***10***
For Defeat of 82-millimeter Contact Burst						
2 by 4	2.0	3	4	4	4	3
	3.0	18	12	8	5	3
	4.0	18	14	7	4	3
2 by 6	2.0	4	7	8	8	6
	3.0	18	18	16	12	8
	4.0	18	18	18	11	7
4 by 4	2.0	7	10	10	9	7
	3.0	18	18	18	12	8
	4.0	18	18	18	10	7
4 by 8	1.5	4	5	7	8	8
	2.0	14	18	18	18	18
	3.0	18	18	18	18	18
For Defeat of 120- and 122-millimeter Contact Bursts						
4 by 8	2.0	–	–	–	–	–
	3.0	–	–	–	–	–
	4.0	3.5	4	5	5	6
	5.0	12	12	12	11	10
	6.0	18	18	18	16	12

Table D-8. Center-to-center spacing for wood supporting soil cover to defeat contact bursts (continued)

Nominal Stringer Size (inches)	*Depth of Soil (d) (feet)*	*Center-to-Center Stringer Spacing (h) (inches), for Cited Span Length (l) (feet)*				
		2	***4***	***6***	***8***	***10***
For Defeat of 120- and 122-millimeter Contact Bursts						
6 by 6	2.0	–	–	–	–	–
	3.0	–	–	–	–	–
	4.0	–	–	5.5	6	6
	5.0	14	14	13	12	10
	6.0	18	18	18	16	12
6 by 8	2.0	–	–	–	–	–
	3.0	–	–	–	–	–
	4.0	5.5	6	8	9	10
	5.0	18	18	18	18	17
8 by 8	2.0	–	–	–	–	–
	3.0	–	–	–	–	–
	4.0	7.5	9	11	12	13
	5.0	18	18	18	18	18
For Defeat of 152-millimeter Contact Burst						
4 by 8	4.0	–	–	–	–	3.5
	5.0	6	6	7	7	7
	6.0	17	16	14	12	10
	7.0	18	18	18	15	11
6 by 6	4.0	–	–	–	–	–
	5.0	7	8	8	8	7
	6.0	18	18	15	12	10
	7.0	18	18	18	15	11
6 by 8	3.0	–	–	–	–	–
	4.0	–	–	–	–	6
	5.0	10	11	12	12	12
	6.0	18	18	18	18	17
8 by 8	3.0	–	–	–	–	–
	4.0	–	–	–	–	8
	5.0	14	15	16	17	16
	6.0	18	18	18	18	18
Note. The maximum beam spacing listed in the above table is 18 inches. This is to preclude further design for roof material placed over the stringers to hold the earth cover. A maximum of 1 inch wood or plywood should be used over stringers to support the earth cover for 82-millimeter bursts; 2 inches should be used for 120-, 122-, and 152-millimeter bursts. A dash indicates no data.						

D-11. Complete other elements of the design using the layout in figure D-1 on page D-1. If logs are to be used for stringers, use table D-9, page D-8, to convert from dimensioned timber to round timber.

Table D-9. Converting dimensioned timber to round timber

Timber (inches)	*Round Timber (inches) (excluding bark)*
4 by 4	5
6 by 6	7
6 by 8	8
8 by 8	10
8 by 10	11
10 by 10	12
10 by 12	13
12 by 12	14
Note. Sizes given are nominal and not rough cut timber.	

DETAILED DESIGN PROCEDURE

D-12. Figure D-4 shows the design calculations that are used to develop the 29-line data in the mathematical process (table D-10, page D-10) used to compute the information required to create a standard stringer roof design. The material in table D-8, page D-6, was arrived at using this process. A roof is designed using the process described in the remainder of this appendix. The design steps are as follows:

- **Step 1.** Use the design equations from figure D-4 or the applied 29-line mathematical process at table D-10 to compute the largest half-buried trinitrotoluene (TNT) charge that the earth-covered roof can safely withstand.
- **Step 2.** Use the charge equivalency table D-11, page D-12 to find the approximate size of the superquick or contact burst round that this half-buried TNT charge equals.
- **Step 3.** Complete the roof structure drawings and the bill of materials.

D-13. Use the equations in figure D-4, applying the applicable values for the geometry, material, and soil properties to design the roof stringers. Alternatively, use the procedure in table D-10.

S – section modulus of stringer (inch^3)
FS – maximum dynamic flexural stress (pounds per square inch) (table D-3)
L – stringer span (foot)
E – modulus of elasticity (kips per square inch)
I – moment of inertia (inch^4)
γ – unit weight of soil (pounds/foot^3)
w – stringer spacing (inch)
d – depth of soil cover (foot)
φ – load and material factor (figure D-5)
C – transmission coefficient (table D-1)

$$A = 0.64\left(\frac{8S \times FS}{12L}\right) \qquad \beta = \sqrt{\frac{264{,}120{,}779\,EI}{\gamma w d L^4}}$$

$$\Gamma = \left[\frac{4}{4 \times \left(\frac{d}{L}\right)^2 + 1}\right]^{1.25} + \left[\frac{1}{1.5\left(\frac{d}{L}\right)^{2.5}}\right]$$

$$\text{Largest half buried charge weight (pounds trinitrotoluene)} = \left[\frac{61.32\left(\frac{A}{\beta}\right)\varphi L^{1.5}}{Cw\Gamma}\right]^{.8571}$$

Figure D-4. Roof stringer design equation

D-14. Table D-10 provides the calculation method for evaluating the largest half-buried line charge weight that a standard stringer roof can withstand. Use figure D-5, page D-14, and figure D-6, page D-15, as required in completing the table.

Table D-10. Standard stringer roof procedure (contact burst rounds)

Line	*Procedure and Result*
1	Enter the unit weight of the soil (pounds per cubic foot) as determined on-site.
2	Enter the proposed depth of soil cover (feet).
3	Enter the S value (inches^3): if wood, from table D-2, page D-3. if steel, from table D-4, page D-4.
4	Enter the stringer spacing (inches).
5	Enter the FS value (psi): if wood, from table D-3, page D-3. if steel, enter 50,000.
6	Enter the stringer span length (feet).
7	Multiply line 1 by line 4, enter result.
8	Multiply line 7 by line 2, enter result.
9A	Multiply line 8 by line 6, enter result.
9B	Multiply line 9A by line 6, enter result.
9C	Divide line 9B by 8, enter result.
9D	Divide line 9C by line 3, enter result.
9E	Divide line 9D by line 5, enter result.
9F	If the line 9E result is greater than 0 but less than 1.0 go to line 10. If line 9E is greater than 1.0, the roof system is overloaded. Then do at least one of the following and recompute from line 1: a. Decrease stringer spacing. b. Decrease span length. c. Use a material with a higher “S” or “FS” value. d. Decrease soil cover.
10	Enter side A of figure D-5, page D-14, with the line 9E value, find the side B value, and enter result: if wood, use μ = 1 curve. if steel, use μ = 10 curve.
11	Enter the E value (10^6 psi): if wood, from table D-3, page D-3. if steel, enter 29.
12A	Enter the I value (inches^4): if wood, from table D-2. if steel, from table D-4.
12B	Multiply line 9A by 0.08333, enter result.
12C	Multiply line 12B by 0.64, enter result.
12D	Divide line 12C by line 9E, enter result.
13	Multiply line 9A by 0.0001078, enter result.

Table D-10. Standard stringer roof procedure (contact burst rounds) (continued)

Line	*Procedure and Result*
14A	Multiply line 12A by line 11, enter result.
14B	Multiply line 6 by line 6, enter result.
14C	Multiply line 14B by line 6, enter result.
14D	Divide line 14A by line 14C, enter result.
14E	Multiply line 14D by 28,472.22, enter result.
15	Divide line 14E by line 13, enter result.
16	Take the square root of line 15, enter result.
17	Divide line 12D by line 16, enter result.
18	Multiply line 10 by line 17, enter result.
19	Divide line 2 by line 6, enter result.
20	Multiply line 19 by line 19, enter result.
21A	Take the square root of line 19, enter result.
21B	Multiply line 21A by line 20, enter result.
22	Divide 0.6666667 by line 21B, enter result.
23A	Multiply line 20 by 4, enter result.
23B	Add 1 to line 23A, enter result.
24	Divide 4 by line 23B, enter result.
25A	Take the square root of line 24, enter result.
25B	Take the square root of line 25A, enter result.
25C	Multiply line 25B by line 24, enter result.
26	Add line 25C to line 22, enter result.
27	Choose a C value from table D-1, page D-2, enter result.
28A	Multiply 61.32 by line 18, enter result.
28B	Take the square root of line 14C, enter result.
28C	Multiply line 28A by line 28B, enter result.
28D	Multiply line 27 by line 4, enter result.
28E	Multiply line 28D by line 26, enter result.
28F	Divide line 28C by line 28E, enter result.
29	Raise line 28F to the 0.8571 power (or use the graph in figure D-6, page D-15), enter result.

Legend:
C value – transmission coefficient
E value – modulus of elasticity
FS value – maximum dynamic flexural stress
I value – inertia
psi – pounds per square inch
S value – section modulus

Table D-11. Charge equivalency table

Round Nomenclature	*Half-Buried TNT Charge Weight (pounds)*
United States Gun and Howitzer Cannons	
75-millimeter gun cannon	1.5
76-millimeter gun cannon	2.0
90-millimeter gun cannon	3.2
120-millimeter gun cannon	10.6
175-millimeter gun cannon	42.2
105-millimeter howitzer cannon	7.7
155-millimeter howitzer cannon	15.34
8-inch howitzer cannon	37.1
United States Mortars	
81-millimeter	2.9
4.2 inch	8.1
(Former) Soviet	
57-millimeter fragmentation	0.5
57-millimeter fragmentation-tracer	0.4
76-millimeter high explosive	1.8
76-millimeter fragmentation	1.1
82-millimeter fragmentation	1.0
85-millimeter fragmentation	1.7
100-millimeter high explosive	4.8
107-millimeter fragmentation-high explosive	5.4
120-millimeter high explosive	8.6
122-millimeter high explosive	10.7
130-millimeter fragmentation-high explosive[1]	10.2
140-millimeter fragmentation-high explosive	8.1
152-millimeter fragmentation-high explosive	14.3
160-millimeter high explosive	16.3
People's Republic of China	
57-millimeter high explosive	0.5
60-millimeter high explosive[2]	4.6
70-millimeter high explosive	1.6
75-millimeter high explosive	2.2
81-millimeter high explosive	1.3
82-millimeter fragmentation	1.1
102-millimeter high explosive	2.8
105-millimeter high explosive	5.3
107-millimeter	3.0
120-millimeter high explosive	6.3

Table D-11. Charge equivalency table (continued)

Round Nomenclature	***Half-Buried TNT Charge Weight (pounds)***
Czechoslovakian,82-millimeter fragmentation	1.3
Czechoslovakian, 85-millimeter fragmentation	1.7
Czechoslovakian, 100-millimeter high explosive	3.5
Czechoslovakian, 120-millimeter high explosive	4.5
Czechoslovakian, 130-millimeter high explosive	5.2
North Korean, 82-millimeter fragmentation	1.2
Polish, 122-millimeter fragmentation	7.4
Yugoslavian, 76-millimeter high explosive	1.6
Yugoslavian, 82-millimeter high explosive	1.1
Yugoslavian, 120-millimeter high explosive	6.9
Finnish, 160-millimeter high explosive	9.3
French, 105-millimeter high explosive plastic	7.1
French, 120-millimeter high explosive[3]	9.7
French, 155-millimeter high explosive	17.5
Israeli, 81-millimeter high explosive	4.9
Israeli, 88-millimeter high explosive	1.9
Italian, 81-millimeter high explosive	4.9

[1] Content of some rounds unknown.
[2] High capacity.
[3] Heavy.

Legend:

TNT – trinitrotoluene

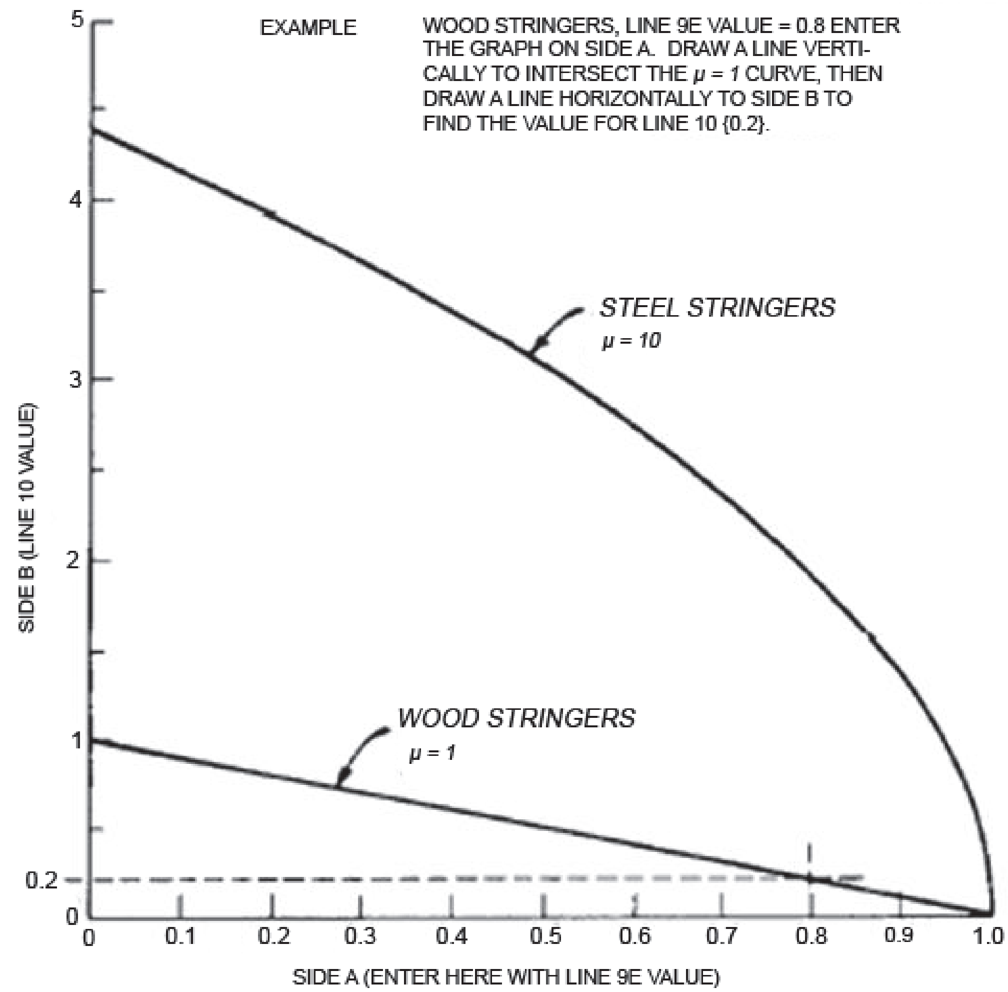


Figure D-5. Comparison graph for stringer relationships

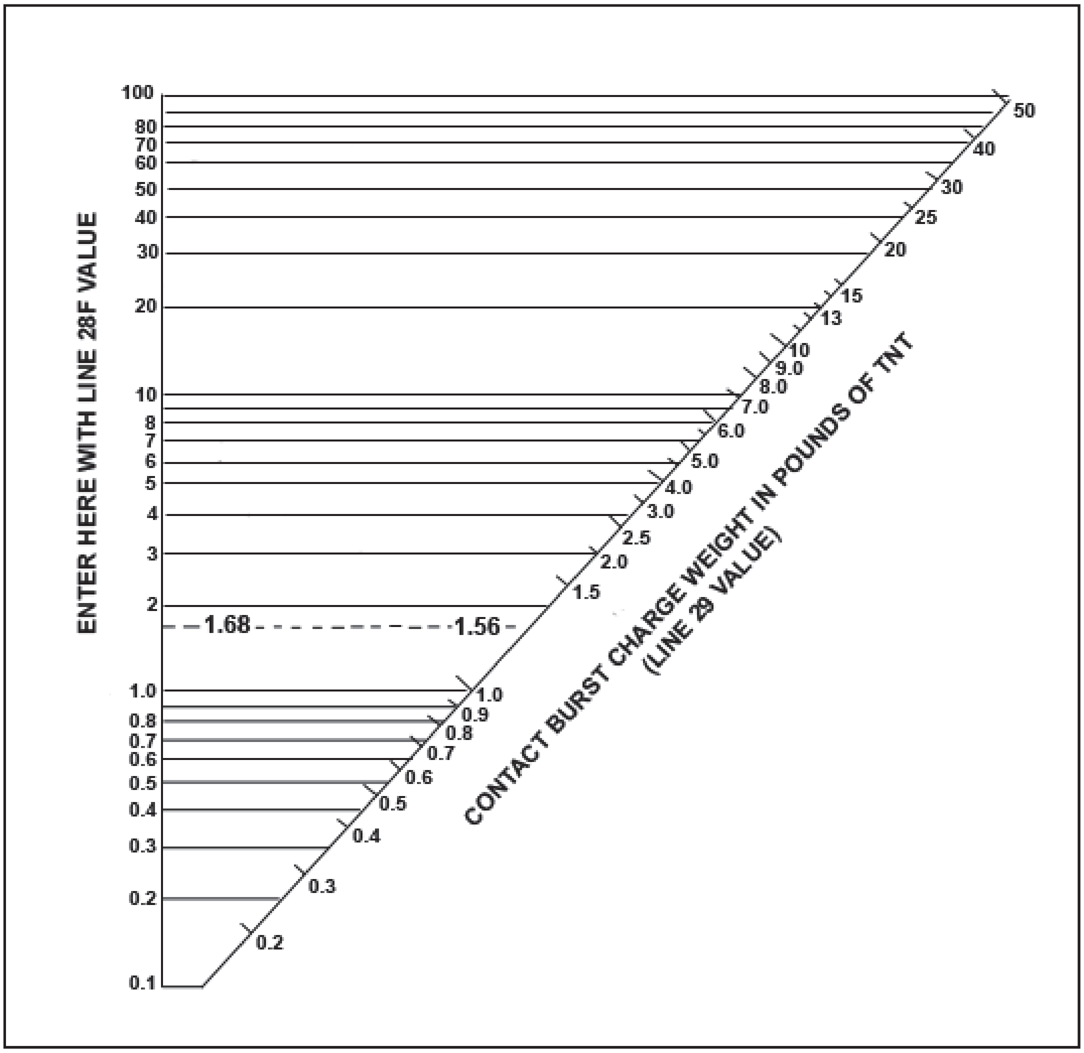


Figure D-6. Quick check chart for roof capability

D-15. The value on line 29 (table D-10, page D-11) is the largest half-buried charge in pounds of TNT that the roof can withstand. Table D-11, page D-12, provides an equivalency of various weapon rounds to a half-buried charge weight of TNT. Enter table D-11 with this value to find the round having an equivalent charge weight equal to or less than the value on line 29. Alternatively, if the threat charge weight (which the unit intelligence officer should be able to provide) is known, compare the equivalent charge weight from table D-10 (line 29) to the threat charge weight. If the charge weight from table D-10 is equal to or greater than the threat charge weight, the roof stringer design is adequate. If it is smaller than the threat charge weight, the roof stringers are underdesigned and either larger stringers must be used or the spacing must be decreased. Note that once the stringer spacing is established, the sheathing thickness will have to be established using table D-5, page D-5.

EXAMPLES USING THE DETAILED DESIGN PROCEDURE

ASSESSMENT OF EXISTING WOOD STRINGER ROOF

Problem

D-16. Given existing defensive positions with wood stringer roofs as shown in figure D-7 determine how much protection these types of positions give against the contact burst of an HE round.

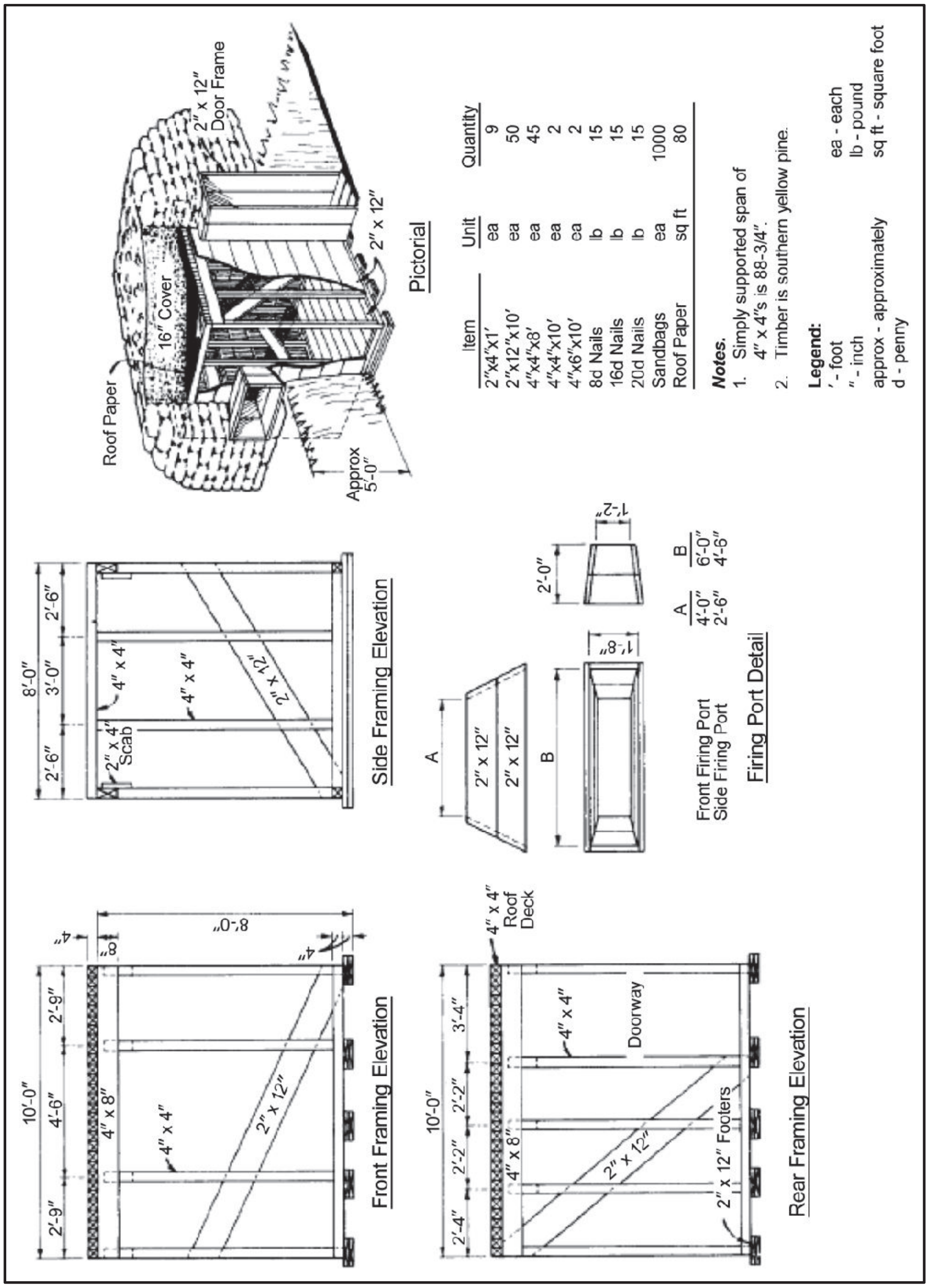


Figure D-7. Existing wood stringer roof example

D-17. The first value in table D-12 is obtained by estimating that the 16-inch-deep soil cover (sand) weighs 100 pounds per cubic foot. Note that the roof is made of 4- by 4-foot stringers, laid side-by-side over a span of 88.75 inches. See table D-12 for more information on the remainder of the calculations.

Table D-12. Example wood stringer roof procedure

Line		***Result***
1	The soil unit weight (pounds per cubic foot) is	100
2	The depth of soil cover (feet) is	16 in+12 in **=** 1.33
3	From table D-2, page D-3, the S value (inches^3) for 4 by 4s is	7.15
4	Since the 4 by 4s are laid side by side, the stringer spacing (inches) is equal to their actual width or 3.5 inches	3.5
5	From table D-3, page D-3, the FS value (psi) for southern pine is	6,000
6	The stringer span length (feet) is	88.75 in ÷ 12 in **=** 7.4
7	Line 1 x line 4 = 100 x 3.5 =	350
8	Line 7 x line 2 = 350 x 1.33 =	465.5
9A	Line 8 x line 6 = 465.5 x 7.4 =	3,444.7
9B	Line 9A x line 6 = 3,444.7 x 7.4 =	25,490.78
9C	Line 9B ÷ 8 = 25,490.78 ÷ 8 =	3,186.35
9D	Line 9C ÷ line 3 = 3,186.35 ÷ 7.15 =	445.64
9E	Line 9D ÷ line 5 = 445.64 ÷ 6,000 =	0.0743
9F	Line 9E value 0.0743 is greater than 0 and less than 1.0, therefore proceed to line 10.	
10	From figure D-5, page D-14, using the μ = 1 curve, the line 10 value is	0.93
11	From table D-3, the E value (10^6 psi) for southern pine is	1.76
12A	From table D-2, the I value (inches^4) for 4 by 4s is	12.51
12B	Line 9A x 0.08333 = 3,444.7 x 0.08333 =	287.05
12C	Line 12B x 0.64 = 287.05 x 0.64 =	183.71
12D	Line 12C ÷ line 9E = 183.71 ÷ 0.0743 =	2,472.6
13	Line 9A x 0.0001078 = 3,444.7 x 0.0001078 =	0.371
14A	Line 12A x line 11 = 12.51 x 1.76 =	22.0176
14B	Line 6 x line 6 = 7.4 x 7.4 =	54.76
14C	Line 14B x line 6 = 54.76 x 7.4 =	405.22
14D	Line 14A ÷ line 14C = 22.0176 ÷ 405.22 =	0.05433
14E	Line 14D x 28,472.22 = 0.05433 x 28,472.22 =	1,547.02
15	Line 14E ÷ line 13 = 1,547.02 ÷ 0.371 =	4,169.87
16	The square root of line 15 = √4169.87 =	64.57
17	Line 12D ÷ line 16 = 2,472.6 ÷ 64.57 =	38.29
18	Line 10 x line 17 = 38.29 x 0.93 =	35.61
19	Line 2 ÷ line 6 = 1.33 ÷ 7.4 =	0.1797
20	Line 19 x line 19 = 0.1797 x 0.1797 =	0.0323
21A	The square root of line 19 = √0.1797 =	0.4239
21B	Line 21A x line 20 = 0.4239 x 0.0323 =	0.0137

Table D-12. Example wood stringer roof procedure (continued)

Line		*Result*
22	0.6666667 ÷ line 21B = 0.6666667 ÷ 0.0137 =	48.69
23A	Line 20 x 4 = 0.0323 x 4 =	0.1292
23B	1 + line 23A = 1 + 0.1292 =	1.1292
24	4 ÷ line 23 B = 4 ÷ 1.1292 =	3.5423
25A	The square root of line 24 = √3.5423 =	1.8821
25B	The square root of line 25A = √1.8821 =	1.3719
25C	Line 25B x line 24 = 1.3719 x 3.5423 =	4.86
26	Line 25 C + line 22 = 4.86 + 48.69 =	53.55
27	From table D-1, the C value chosen for bagged pit run sand is	140
28A	61.32 x line 18 = 61.32 x 35.61 =	2,183.61
28B	The square root of line 14C = √405.22 =	20.13
28C	Line 28A x line 28B = 2,183.61 x 20.13 =	43,955.97
28D	Line 27 x line 4 = 140 x 3.5 =	490
28E	Line 28D x line 26 = 490 x 53.55 =	26,239.5
28F	Line 28C ÷ Line 28E = 43,955.97 ÷ 26,239.5 =	1.675
29	Enter figure D-6, page D-15, with the line 28 F value (1.68) and read the TNT charge weights (pounds)	1.56
	Or, as an alternative method, raise 1.68 to the 0.8571 power.	

Legend:
C value – transmission coefficient
E value – modulus of elasticity
FS value – maximum dynamic flexural stress
I value – inertia
psi – pounds per square inch
S value – section modulus
TNT– trinitrotoluene

Solution

D-18. Consequently, the largest TNT charge that the roof can withstand is 1.56 pounds. Entering on table D-11, page D-12, with this value, find that the roof will withstand a contact burst explosion of up to an 82-millimeter fragmentation round (only 1.0-pound charge size) excluding the 76-millimeter HE round (1.8-pound charge site).

Steel Stringer Roof

Problem

D-19. The 2-76th Infantry Battalion will occupy the positions described in the previous example for an extended period of time. The commander has ordered the 1st Platoon of A/52d Engineers to construct a CP. This structure must have at least 10 feet by 12 feet of floor space and be capable of defeating a contact burst of a former Soviet 152-millimeter round. The S-2 reports that 13 undamaged 8-inch by 6 ½-inch wide flange beams have been found. They are long enough to span 10 feet and can be salvaged from the remains of a nearby demolished railroad bridge.

D-20. Design a roof for the CP using these beams as stringers. Plan to place five of the stringers on 36-inch centers and cover them with a 4- by 4-foot wood deck. Use the same bagged sand as described in the first example. Begin design by assuming that the soil cover will be 3 feet deep. See table D-13 for more information on the calculation.

Table D-13. Example steel stringer roof procedure

Line		*Result*
1	The soil unit weight (pounds per cubic foot) is	100
2	The assumed depth of soil cover (feet) is	3
3	From table D-4, page D-4, the S value (inches^3) for the 8 by 6 ½ steel is	20.8
4	The stringer spacing (inches) is	36
5	For steel stringers, the FS value (psi) is	50,000
6	The stringer span length (feet) is	10
7	Line 1 x line 4 = 100 x 36 =	3,600
8	Line 7 x line 2 = 3,600 x 3 =	10,800
9A	Line 8 x line 6 = 10,800 x 10 =	108,000
9B	Line 9A x line 6 = 108,000 x 10 =	1,080,000
9C	Line 9B ÷ 8 = 1,080,000 ÷ 8 =	135,000
9D	Line 9C ÷ line 3 = 135,000 ÷ 20.8 =	6,490.38
9E	Line 9D ÷ line 5 = 6,490.38 ÷ 50,000 =	0.1298
9F	Line 9E value 0.1298 is greater than 0 and less than 1.0, therefore proceed to line 10.	
10	From figure D-5, page D-14, using the μ = 10 curve, the line 10 value is (see example in figure D-5)	4.05
11	For steel stringers the E value (10 ^{6} psi) is	29
12A	From table D-4, page D-4, the I value (inches^4) for the 8 by 6 ½ inch steel is	02.5
12B	Line 9A x 0.08333 = 108,000 x 0.08333 =	8,999.64
12C	Line 12B x 0.640 = 8,999.64 x 0.64 =	5,759.77
12D	Line 12C ÷ line 9E = 5,759.77 ÷ 0.1298 =	44,374.19
13	Line 9A x 0.0001078 = 108,000 x 0.0001078 =	11.64
14A	Line 12A x line 11 = 82.5 x 29 =	2,102.5
14B	Line 6 x line 6 = 10 x 10 =	100
14C	Line 14B x line 6 = 100 x 10 =	1,000
14D	Line 14A ÷ line 14 C = 2,392.5 ÷ 1,000 =	2.39
14E	Line 14D x 28,472.22 = 2.39 x 28,472.22 =	68,048.61
15	Line 14E ÷ line 13 = 68,048.61 ÷ 11.64 =	5,846.10
16	The square root of line 15 = √5,846.10 =	75.56
17	Line 12D ÷ line 16 = 44,374.19 ÷ 76.46 =	580.36
18	Line 10 x line 17 = 4.05 x 580.36 =	2,350.46
19	Line 2 ÷ line 6 = 3 ÷ 10 =	0.3
20	Line 19 x line 19 = 0.3 x 0.3	0.09
21A	The square root of line 19 = √0.3 =	0.5477
21B	Line 21A x line 20 = 0.5477 x 0.09 =	0.0493
22	0.6666667 ÷ line 21B = 0.6666667 ÷ 0.0493 =	13.52
23A	Line 20 x 4 = .09 x 4 =	0.36
23B	1 + line 23A = 1 + 0.36 =	1.36

Table D-13. Example steel stringer roof procedure (continued)

Line		*Result*
24	4 ÷ line 23B = 4 ÷ 1.36	2.94
25A	The square root of line 24 = √2.94 =	1.71
25B	The square root of line 25A = √1.71 =	1.31
25C	Line 25B x line 24 = 1.31 x 2.94 =	3.85
26	Line 25C + line 22 = 3.85 + 13.52 =	17.37
27	From table D-1, page D-2, the C value chosen for the bagged pit run sand is	140
28A	61.32 x line 18 = 61.32 x 2,350.46 =	144,130.21
28B	The square root of line 14C = √1,000 =	31.62
28C	Line 28A x line 28B = 144,130.21 x 31.62 =	4,557,397.24
28D	Line 27 x line 4 = 140 x 36 =	5,040
28E	Line 28D x line 26 = 5,040 x 17.37 =	87,544.80
28F	Line 28C ÷ line 28 E = 4,557,397.24 ÷ 87,544.80 =	52.06
29	Enter figure D-6, page D-15, with the line 28F value (52.06) and read the TNT charge weight (pounds)	29.6
Or, as an alternate method, raise 52.06 to the 0.8571 power.		
Legend: C value – transmission coefficient E value – modulus of elasticity FS value – maximum dynamic flexural stress I value – inertia psi – pounds per square inch S value – section modulus TNT– trinitrotoluene		

Solution

D-21. Consequently, the largest TNT charge that the stringers can withstand is 29.6 pounds. Use the procedure again in a manner similar to that in previous examples to evaluate the 4- by 4-foot wood deck. Find a line 29 value of 29.64. Enter table D-11, page D-12, with the largest of these values (29.6) and find that the roof will withstand a contact burst explosion of up to one 160-millimeter HE round (only 16.3-pound charge size). The designed roof will be capable of defeating a contact burst of a former Soviet 152-millimeter round.

Appendix E

Guidelines for Standing Operating Procedures

SOPs are critical to battlefield success. All commanders should establish survivability guidelines in their SOPs and ensure that their Soldiers/Marines are familiar with them. SOPs provide guidelines that help reduce the time required to perform routine tasks. Commanders can achieve these ends by defining the responsibilities, identifying the expected tasks, and providing supervisors with a memory aid when planning or inspecting. SOPs, coupled with battle drills (appendix F), provide units with guidance on how to execute anticipated battlefield tasks. Constructing and improving fighting and protective positions, and constructing or employing camouflage and concealment, are tasks that should be routine for all units.

CONTENT

E-1. The following considerations may be included in a unit SOP:

- A review of survivability fundamentals.
- Priorities of work for camouflage, concealment, and fighting and protective positions.
- Individual and unit basic loads of tools, equipment, and supplies for camouflage, concealment, and fighting and protective positions (including who carries them, where or how they're carried, who allocates and controls them, and so on).
- Unit tracking tools/commander's cards for survivability operations.
- Memory aids for supervisors, which should include an inspection checklist and a chart of an enemy's sensor systems with possible countermeasures. (See figure E-1, pages E-2 through E-4, for a sample camouflage and concealment checklist. See GTAs 05-08-001 and 07-06-001 for checklists on cover.)
- Guidelines on camouflage and concealment discipline to provide uniformity among all subunits.
- Procedures for blackout, the quartering party, unit movement, and the deployment area.
- Appropriate camouflage and concealment postures in OPORDs for different missions.

COMMANDERS' RESPONSIBILITIES

E-2. Commanders ensure that each Soldier/Marine has the required quantities of serviceable uniforms and that these uniforms are properly maintained to protect their infrared screening properties. Based on unit requirements, supply personnel forecast, request, and store adequate quantities of expendable supplies for camouflage and concealment (paint, makeup, and repair kits) and for survivability positions (stakes, pickets, and sandbags). Commanders ensure that authorized quantities of camouflage and concealment screens (LCSS) and support systems (to include repair kits and spare parts) and tools for construction of survivability positions are on hand and maintained in a clean, serviceable condition.

FRATRICIDE

E-3. Since warfare often results in the loss of life from fratricide, the unit SOP should include ways to reduce fratricide. Commanders consider ways for friendly units to identify each other on the battlefield. Fratricide compels commanders to consider the effect camouflage and concealment and deception operations have on the necessity of being recognized by friendly troops.

1. Command Emphasis.
    a. The commander—
        (1) Establishes camouflage and concealment goals.
        (2) Executes camouflage and concealment plans.
        (3) Inspects frequently for camouflage and concealment deficiencies.
        (4) Conducts follow-up inspection of camouflage and concealment deficiencies.
        (5) Integrates camouflage and concealment into training exercises.
    b. The unit—
        (1) Integrates camouflage and concealment into its SOP.
        (2) Follows the SOP.
2. Discipline.
    a. The unit—
        (1) Observes noise discipline.
        (2) Observes light discipline with respect to smoking, fires, and lights.
        (3) Conceals highly visible equipment.
        (4) Covers shiny surfaces.
        (5) Keeps exposed activity to a minimum.
        (6) Uses cut vegetation properly.
        (7) Uses and conceals dismount points properly.
    b. Soldiers/Marines—
        (1) Wear the correct uniform.
        (2) Control litter and spoil.
3. Techniques. The unit properly and effectively—
    a. Places and disperses vehicles and equipment.
    b. Disperses elements of the CP.
    c. Employs camouflage nets (LCSS).
    d. Uses (or minimizes) shadows.
    e. Minimizes movement.
    f. Hides operations and equipment.
    g. Blends operations and equipment with backgrounds.
    h. Employs pattern-painting techniques.
    i. Employs decoys.
    j. Integrates obscuration with unit movement.
    k. Practices individual camouflage and concealment of the Soldier's/Marine's—
        (1) Helmet.
        (2) Face.
        (3) Weapon(s).
        (4) Other equipment.

Figure E-1. Sample camouflage and concealment checklist

l. Employs camouflage and concealment on fighting positions by properly—
   (1) Eliminating or minimizing target silhouettes.
   (2) Practicing spoil control.
   (3) Eliminating or minimizing regular or geometric shapes and layout.
   (4) Maintaining overhead concealment.
   (5) Practicing dust control.

m. Employs camouflage and concealment on tactical vehicles by—
   (1) Minimizing and concealing track marks.
   (2) Minimizing or eliminating the shine on vehicles and equipment.
   (3) Reducing or using shadows to the unit's advantage.
   (4) Employing camouflage nets (LCSS).
   (5) Painting vehicles to match their surroundings.
   (6) Dispersing vehicles and equipment.
   (7) Concealing vehicles and supply routes.
   (8) Controlling litter and spoil.
   (9) Storing and concealing ammunition.

n. Employs camouflage and concealment on AAs by—
   (1) Facilitating mission planning for access and egress concealment.
   (2) Marking guideposts for route junctions.
   (3) Ensuring that turns are not widened by improper use.
   (4) Dispersing dismount, mess, and maintenance areas.
   (5) Dispersing elements of the CP.
   (6) Maintaining camouflage and concealment by—
      (a) Inspecting camouflage and concealment frequently.
      (b) Controlling litter and garbage.
      (c) Observing blackout procedures.
   (7) Observing evacuation procedures by—
      (a) Policing the area.
      (b) Covering or eliminating tracks.
      (c) Preventing traffic congestion.
      (d) Concealing spoil.

o. Employing camouflage and concealment on the CP by—
   (1) Ensuring that LOCs are not converged.
   (2) Dispersing vehicles.
   (3) Ensuring that turn-ins are not widened through improper use.
   (4) Ensuring that protective barriers follow terrain features.
   (5) Concealing defensive weapons.
   (6) Digging in the CP (when in open areas).
   (7) Maintaining camouflage nets (LCSS).

Figure E-1. Sample camouflage and concealment checklist (continued)

- (8) Using civilian buildings properly and—
  - (a) Controlling access and egress.
  - (b) Observing blackout procedures.
  - (c) Avoiding obvious locations.

p. Employing camouflage and concealment on supply points by—
- (1) Dispersing operations.
- (2) Concealing access and egress routes.
- (3) Using the track plan.
- (4) Providing concealed loading areas.
- (5) Developing and implementing a schedule for the units being serviced.

q. Employing camouflage and concealment on water points by—
- (1) Concealing access and egress routes.
- (2) Ensuring that the track plan is used.
- (3) Controlling spillage.
- (4) Controlling shine and reflections.
- (5) Developing and implementing a schedule for the units being serviced.

Legend:

AA	assembly area
CP	command post
LCSS	Lightweight Camouflage Screen System
LOC	line of communications
SOP	standing operating procedure

Figure E-1. Sample camouflage and concealment checklist (continued)

Appendix F
Other Camouflage Considerations

This appendix provides other camouflage considerations and information. It addresses the LCSS, individual camouflage and concealment, standard camouflage materials, camouflage of medical facilities.

LIGHTWEIGHT CAMOUFLAGE SCREEN SYSTEM

F-1. The LCSS is a modular system consisting of a hexagon screen, a diamond-shaped screen, a support system, and a repair kit. Any number of screens can be joined to cover a designated target or area.

F-2. The LCSS protects targets in four different ways. It—

- Casts patterned shadows that break up the characteristic outlines of a target.
- Scatters radar returns (except when radar-transparent nets are used).
- Traps target heat and allows it to disperse.
- Simulates color and shadow patterns that are commonly found in a particular region.

Notes.

1. The section on standard camouflage materials (see paragraph F-19) includes ordering information for LCSS.

2. See FM 5-34/MCRP 3-17A and TM 5-1080-200-13&P for more information on the characteristics and capabilities, erecting procedures, maintenance, procedures for determining the number of modules needed for camouflaging a given area, and common vehicle dimensions.

SUPPLEMENTAL CAMOUFLAGE

F-3. LCSSs are often employed in conjunction with supplemental camouflage because nets alone do not make assets invisible to a threat's multispectral sensors. Use other camouflage and concealment techniques to achieve effective concealment. Cover or remove all reflective surfaces (mirrors, windshields, lights). Also ensure that the target's shadow is disrupted or disguised. Use native vegetation, because placing a target in dense foliage provides natural concealment and a smoother transition between the edges of the camouflage net and the target's background. Cover exposed edges of the net with dirt or cut vegetation to enhance the transition.

TRAINING

F-4. Units should develop and practice battle drills that cover the requirements and procedures for erecting nets over assigned equipment. Table F-1, page F-2, shows a sample battle drill for the crew of an infantry fighting vehicle.

Table F-1. Sample battle drill

Standards: • Complete camouflage net setup drills within 20 minutes. • Complete camouflage net teardown drills within 15 minutes.
Personnel Required: Three crew members.
Equipment Required: Two modules or the following items: • Nets, hexagonal, 2 each. • Nets, diamond, 2 each. • Pole sections, 24 each. • Stakes, 36 each. • Lanyards, 6 each. • Spreaders, 12 each.
Stowage Location: The camouflage net is strapped to the right side of the trim vane.
Setup Drill: • The gunner and the assistant gunner remove the camouflage net from the trim vane and place it on top of the vehicle. • The driver removes poles and stakes from the bag and places them around the vehicle. • The gunner and the assistant gunner remove the vehicle's antenna, position the net on top of the vehicle, and roll the net off the sides of the vehicle. • The driver stakes the net around the vehicle. • The driver and the assistant gunner assemble poles and spreaders and then erect the net. • The gunner inspects the camouflage from a distance. • The crew adjusts the camouflage as necessary.
Teardown Drill: • The driver and the assistant gunner take down and disassemble poles and spreaders. • The gunner and the assistant gunner unstake the net and roll it to the top of the vehicle. • The gunner and the assistant gunner complete rolling the net on top of the vehicle and replace the vehicle's antenna. • The driver stores the net on the trim vane. • The gunner and the assistant gunner store poles, spreaders, and stakes on the trim vane.
Note. Preassemble the nets before placing them on the vehicle. Supplement camouflage nets by properly placing vehicles and using natural vegetation.

INDIVIDUAL CAMOUFLAGE AND CONCEALMENT

F-5. Soldiers/Marines are responsible for camouflaging themselves, their equipment, and their positions. Camouflage and concealment reduces the probability of an enemy placing aimed fire on a Soldier/Marine.

MATERIALS

F-6. Use natural and artificial materials for camouflage and concealment. Natural camouflage and concealment includes defilade, grass, bushes, trees, and shadows. Artificial camouflage and concealment for Soldiers/Marines includes certain uniforms, camouflage nets, skin paint, and natural materials removed

from their original positions. To be effective, artificial camouflage and concealment must blend with the natural background.

DISCIPLINE

F-7. Noise, movement, and light discipline contribute to individual camouflage and concealment as follows:

- Noise discipline muffles and eliminates sounds made by Soldiers/Marines and their equipment.
- Movement discipline minimizes movement within and between positions and limits movement to routes that cannot be readily observed by an enemy.
- Light discipline controls the use of lights at night. Avoid open fires, do not smoke tobacco in the open, and do not walk around with a lit flashlight.

DISPERSAL

F-8. Dispersal is the deliberate deployment of Soldiers/Marines and equipment over a wide area. It is a key individual survival technique. Dispersal creates a smaller target mass for enemy sensors and weapons systems. Proper dispersal reduces casualties and losses in the event of an attack and also makes enemy detection efforts more difficult.

CONSIDERATIONS

F-9. Soldiers/Marines should have a detailed understanding of the recognition factors described in chapter 6. While all of these factors remain important when applying individual camouflage and concealment, the following factors are critical:

- **Movement.** Movement draws attention, whether it involves vehicles on the road or individuals walking around positions. The naked eye, infrared, and radar sensors can detect movement. Minimize movement while in the open and remember that darkness does not prevent observation by an enemy equipped with modern sensors. When movement is necessary, slow, smooth movement attracts less attention than quick, irregular movement.
- **Shape.** Use camouflage and concealment materials to break up the shapes and shadows of positions and equipment. Stay in the shadows whenever possible, especially when moving, because shadows can visually mask objects. When conducting operations close to an enemy, disguise or distort helmet and body shapes with artificial camouflage and concealment materials to make it more difficult for an enemy to recognize them.
- **Shine and light.** Shine can also attract attention. Pay particular attention to light reflecting from smooth or polished surfaces (mess kits, mirrors, eyeglasses, watches, windshields, and starched uniforms). Plastic map cases, dust goggles worn on top of a helmet, and clear plastic garbage bags also reflect light. Cover these items or remove them from exposed areas. Vehicle headlights, taillights, and safety reflectors not only reflect light but also reflect laser energy used in weapon systems. Cover this equipment when the vehicle is not in operation.

  Red filters on vehicle dome lights and flashlights, while designed to protect Soldiers'/Marines' night vision, are extremely sensitive to detection by NVDs. A tank's red dome light, reflecting off the walls and out through the sight and vision blocks, can be seen with a starlight scope from 4 kilometers. Red-lensed flashlights and lit cigarettes and pipes are equally observable. To reduce the chances of detection, replace red filters with blue-green filters and practice strict light discipline. Use measures to prevent shine at night because moonlight and starlight can be reflected as easily as sunlight.
- **Color.** The contrast of skin, uniforms, and equipment with the background helps an enemy detect opposing force. Individual camouflage and concealment should blend with the surroundings; or at a minimum, objects must not contrast with the background. Ideally, blend colors with the background or hide objects with contrasting colors.

F-10. Disguise is an effective means of camouflage, especially for isolated personnel. During the evasion portion of personnel recovery operations, isolated personnel may use civilian clothing to disguise

themselves. However, they must retain their military identification card as proof of status and should not commit belligerent acts while using a disguise. Additionally, protected emblems (such as Red Cross or Red Crescent) may not be used for purposes of evasion and escape. See ATP 3-50.3/ NTTP 3-50.3/AFTTP(I) 3-2.26, and JP 3-50 for additional information on evasion and personnel recovery operations.

> ***Note.*** See FM 3-05.222 for additional concealment considerations for snipers.

EMPLOYMENT

F-11. Study nearby terrain and vegetation before applying camouflage and concealment to Soldiers/Marines, equipment, or fighting positions. During reconnaissance, analyze the terrain in concert with the camouflage and concealment considerations listed above, and then apply camouflage and concealment materials that best blend with the area. Change camouflage and concealment as required when moving from one area to another.

Skin

F-12. Exposed skin reflects light and may draw attention. Even very dark skin, because of natural oils, will reflect light. Camouflage paint sticks cover these oils and help blend skin with the background. Avoid using oils or insect repellent to soften the paint stick because doing so makes the skin shiny and defeats the purpose of camouflage paint. Soldiers/Marines applying camouflage paint should work in pairs and help each other. Self-application may leave gaps, such as behind ears. Use the following techniques:

- Paint high, shiny areas (forehead, cheekbones, nose, ears, and chin) with a dark color.
- Paint low, shadow areas with a light color.
- Paint exposed skin (back of neck, arms, and hands) with an irregular pattern.

F-13. When camouflage paint sticks are unavailable, use field expedients such as burnt cork, bark, charcoal, lampblack, or mud. Mud contains bacteria, some of which is harmful and may cause disease or infection, so consider mud as the last resource for individual camouflage field-expedient paint.

Uniforms

F-14. Many uniforms have a camouflage pattern but often require additional camouflage, especially in operations occurring very close to the enemy. Attach leaves, grass, small branches, or pieces of LCSS to uniforms and helmets. These items help distort the shape of a Soldier/Marine, and they blend with the natural background. Some uniforms provide visual and near-infrared camouflage and concealment. Do not starch these uniforms because starching counters the infrared properties of the dyes. Replace excessively faded and worn uniforms because they lose their camouflage and concealment effectiveness as they wear.

Equipment

F-15. Inspect personal equipment to ensure that shiny items are covered or removed. Take corrective action on items that rattle or make other noises when moved or worn. Soldiers/Marines assigned equipment, such as vehicles or generators, should be knowledgeable of their appropriate camouflage techniques (see chapter 6).

Individual Fighting Positions

> ***Note.*** Review the procedures for camouflaging positions in chapter 6, which include considerations for camouflaging individual positions.

F-16. While building a fighting position, camouflage it and carefully dispose of earth spoil. Remember that too much camouflage and concealment material applied to a position can actually have a reverse effect and disclose the position to the enemy. Obtain camouflage and concealment materials from a dispersed area to avoid drawing attention to the position by the stripped area around it.

F-17. Camouflage a position as it is being built. To avoid disclosing a fighting position, never—

- Leave shiny or light-colored objects exposed.
- Remove shirts while in the open.
- Use fires.
- Leave tracks or other signs of movement.
- Look up when aircraft fly overhead. (One of the most obvious features on aerial photographs is the upturned faces of Soldiers/Marines.)

F-18. When camouflage and concealment is complete, inspect the position from an enemy's viewpoint if possible. Check camouflage and concealment periodically to see that it stays natural-looking and conceals the position. When camouflage and concealment materials become ineffective, change or improve them.

STANDARD CAMOUFLAGE MATERIALS

F-19. Standard camouflage items available to Soldiers/Marines are ordered through normal unit-procurement channels. Information and assistance can be obtained from the Defense Logistics Agency Customer Information Service, Battle Creek, Michigan, DSN 661-7766 or commercial 1-877-352-2255 or (269) 961-7766, or via email at dlacontactcenter@dla.mil. (See <http://www.logisticsinformationservice.dla.mil/cust.asp> for additional information.)

THE GENEVA EMBLEM AND CAMOUFLAGE OF MEDICAL FACILITIES

F-20. North Atlantic Treaty Organization standardization agreement (STANAG) 2931 provides for camouflage of the Geneva emblem on medical facilities where the lack of camouflage could compromise tactical operations. Such an order is considered temporary and must be rescinded as soon as the tactical situation permits. This STANAG requires signatories to display the Geneva emblem (a red cross) on medical facilities to help identify and protect the sick and wounded. STANAG 2931 defines medical facilities as medical units, medical vehicles, and medical aircraft on the ground. The camouflage of large, fixed medical facilities exceeds the guidelines of STANAG 2931.

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Glossary

The glossary lists acronyms/abbreviations and terms with Army, Marine Corps, or joint definitions, and other selected terms. Where Army, Marine Corps and joint definitions are different, those differences are noted. Terms or acronyms for which ATP 3-37.34/MCWP 3-17.6 is the proponent manual (the authority) are marked with an asterisk (*).

SECTION I–ACRONYMS AND ABBREVIATIONS

Acronym/Term	Definition
AA	assembly area
ADP	Army doctrine publication
AFCS	Army Facilities Component System
AFTTP(I)	Air Force tactics, techniques, and procedures (interservice)
AMD	air and missile defense
AO	area of operations
ARRK	automated route reconnaissance kit
AT	antitank
ATGM	antitank guided missile
ATP	Army techniques publication
ATTP	Army tactics, techniques, and procedures
BCT	brigade combat team
BP	battle position
CBRN	chemical, biological, radiological, and nuclear
COA	course of action
CONEX	container express
CP	command post
DA	Department of the Army
DOD	Department of Defense
DSN	Defense Switched Network
EA	engagement area (Army/Marine Corps)
ECP	entry control point
EH	explosive hazard
EM	electromagnetic
ERDC	United States Army Engineer Research and Development Center
FARP	forward arming and refueling point
FFE	field force engineering
FLIR	forward-looking infrared
FM	field manual (Army)
GATER	geospatial assessment tool for engineering reachback
GTA	graphic training aid
HE	high explosive

Acronym/Term	Definition
HEAT	high explosive antitank
IED	improvised explosive device
IPB	intelligence preparation of the battlefield (Army)/intelligence preparation of the battlespace (Marine Corps)
JP	joint publication
LCSS	Lightweight Camouflage Screen System
LOC	line of communications
LOS	line of sight
M/CM/S	mobility, countermobility, and/or survivability (joint adds and/or)
MAGTF	Marine air-ground task force
MCDP	Marine Corps doctrine publication
MCIP	Marine Corps interim publication
MCRP	Marine Corps reference publication
MCWP	Marine Corps warfighting publication
METT-T	mission, enemy, terrain and weather, troops and support available—time available
METT-TC	mission, enemy, terrain and weather, troops and support available-time available and civil considerations (Army)
MILVAN	military van (container)
MTI	moving target indicator
NCO	noncommissioned officer
NTTP	Navy tactics, techniques, and procedures
NVD	night vision device
OPORD	operation order
OPSEC	operations security
POL	petroleum, oil, and lubricants
RCT	regimental combat team
RPG	rocket propelled grenade
S-2	battalion or brigade intelligence staff officer (Army; Marine Corps battalion or regiment)
S-3	battalion or brigade operations staff officer (Army; Marine Corps battalion or regiment)
S-4	battalion or brigade logistics staff officer (Army; Marine Corps battalion or regiment)
SOP	standing operating procedure
SSA	Simplified Survivability Assessment
STANAG	standardization agreement (North Atlantic Treaty Organization)
TAA	tactical assembly area
TC	training circular
TCMS	Theater Construction Management System
TETK	Tele-engineering Toolkit
TNT	trinitrotoluene

Acronym/Term	Definition
TOW	tube launched, optically tracked, wire guided
TTP	tactics, techniques, and procedures
UFC	Unified Facilities Criteria
UROC	United States Army Corps of Engineers Reachback Operations Center
U.S.	United States
USACE	United States Army Corps of Engineers
USAES	United States Army Engineer School
UXO	unexploded ordnance
VBIED	vehicle-borne improvised explosive device

SECTION II–TERMS

***survivability**

(Army/Marine Corps) A quality or capability of military forces which permits them to avoid or withstand hostile actions or environmental conditions while retaining the ability to fulfill their primary mission.

***survivability operations**

(Army/Marine Corps) Those military activities that alter the physical environment to provide or improve cover, concealment, and camouflage.

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